Specialized Oil Publications of
THE GULF PUBLISHING COMPANY
Box 2608, Houston (1), Texas

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

WORLD OIL (formerly The Oil Weekly)
and The COMPOSITE CATALOG
for the drilling-producing-pipe line industry

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Single copies 35 cents (except special issues), Subscription price, domestic and foreign $2.00 a year; 2 years $3.00; 3 years $4.00. Advertising rates on application.
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Petroleum Refiner is Indexed by Industrial Arts Index.

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PETROLEUM REFINER

Specialized for the manufacturing division of the petroleum industry, refining, petro-chemical processing, cycling and natural gasoline operations.

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NEW

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VOLUME 27, NO. 5 MAY, 1948

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SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETROCHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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THE LOOK BOX

AN INTERESTING discussion of the part of the average income of a citizen taken by the government (federal, state, county and city), as compared with what he may spend himself, is contained in an article by F. A. Harper, published in a booklet issued by the Foundation for Economic Education.

Taxes and You—A Discussion

Harper says that in 1946 the government took in direct and indirect taxes 31 cents out of every dollar. This compared with an average of 18 cents for food, and an additional 14 cents for housing and all aspects of its operation. Thus, according to Harper, the government took only one cent less out of the average person's income than he spent on food, housing, and household operation.

Or, putting it another way, the government took more than half as much as you paid for food, clothes, housing, doctor bills, funeral bills—in fact everything you spent. The remaining eight cents, he calculates, went into savings.

Says Harper: When all of your income goes to government you will be, in effect, the slave of government. He is concerned, and so are we, with the increasing percentage government is taking. From the Civil War to World War I, all government (in the United States of America) took about 9 cents out of the citizen's dollar. In the twenties it ran up to 13 cents. In 1930 it jumped to 25 cents.

Food for thought. Here we are fighting the idea of the socialized state when we are approaching it via the tax route!

EXPERTS both technical and political continue to offer sage advice to our industry. Much of their counsel is based on accurate information and sound judgment. In the field of synthetic fuel development we have enjoyed the benefits of a series of predictions and explanations that forecast the volume production of liquid hydrocarbon fuels and chemicals from natural gas and eventually from coal reserves. Discussion lately has centered around the requirements of national defense, so that the already complex situation occasioned by steadily mounting peacetime oil needs now become even more involved.

Form of Energy Today and Tomorrow

It is generally agreed that the oil industry is operating at near-maximum capacity, in view of existing facilities, the rate at which new installations can be built, and the present utilization of fuels in this country. Exploration and crude oil production occasion some concern, mainly in view of future needs and decreasing reserves, but presently are not bottlenecks.

Forecasters have tended to piecemeal treatment of the supply-demand situation, possibly because of the wide ramifications of synthetic fuel technology and economics. Whatever the reasons, the impression has become general that the limits of presently employed oil finding and manufacturing methods have been nearly reached, that further mechanization based on liquid fuel consumption

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must depend upon synthol or hydrogenation plants. This is far from the truth.

Getting down to cases, our present national utilization of oil fuels with relation to the other available sources of heat energy is not too efficient. Certainly liquid fuels are almost mandatory for use in airplanes, automobiles, trucks, tractors, and a variety of miscellaneous portable equipment. Petroleum oils are essential for the great bulk of lubrication services. Military equipment, combat vehicles and combat ships, work best for the most part on liquid fuels, and in such services only the best performance possible is acceptable.

Above these special needs, there are a variety of smaller volume services for which petroleum is essential, but much of the distillate fuel and residual fuel oil that constitutes so large a portion of our total oil consumption could quite satisfactorily be replaced with other sources of energy. In theory, perhaps 25 percent of our total oil consumption might be saved by such substitution. In actuality, the saving that is finally made will depend on economic factors.

Certainly, from the conservationist viewpoint, there is no logic in the use of fuel oils for industrial and residential heating near coal mining sections of our country. The diesel locomotives that are replacing coal-burners on so many railroads may present operating advantages to the carriers, but they are not helping the oil supply situation. Diesel fuel specifications limited to straight run gasoils aren't very realistic, either, and since catalytically cracked stocks make satisfactory diesel fuels there seems to be every reason for routing a maximum of our straight run gasoils to cracking plants.

There is good prospect that improvements in coal mining techniques and possibly the mine site gasification of coal will do much to make this form of energy more available for industrial use. Possibly the coal industry, especially the labor unions, can eventually reach some degree of stabilization to insure a steady and dependable production of this essential fuel. It is ridiculous but tragic that a major factor in industry's steady shift to liquid fuels has been the almost complete irresponsibility of the sources of coal supply.

Whatever plans we do make for synthetic fuel manufacture will be profoundly influenced by the efficiency with which we utilize our petroleum fuels. Price differentials, as demand increases, will do much to aid in the conservation of liquid fuels. We should not, probably will not, continue to use liquid fuels for services that can be satisfactorily met with coal or coal gasification, at that time in the future when the manufacture of synthetic liquid fuels becomes necessary.

Another Rugged Individualist Gone

R. L. DUDLEY

ONE by one the old timers, the rugged individualists who helped to build the oil industry in the days of Midwest petroleum pioneering, are passing off the scene. Dan Moran, former president of Continental Oil Company, who died early in April, was one of these.

To some fall the duty of dealing with the scientific problems of the industry; to others the duty of handling financial matters. Some there have been who did their fine work with little or no organization; others found a combination of different jobs at home or abroad.

To a few fall the distasteful jobs of having to put into effect necessary but drastic actions ordered by the board of a company because of economic reasons. Dan Moran had all of the foregoing jobs save the third. And the job he hated most, he confided to close friends, was the three-time job he was given of making drastic reductions in personnel. "Nobody knows how much I hated it," he said, "but it was a job given me and I had to do it."

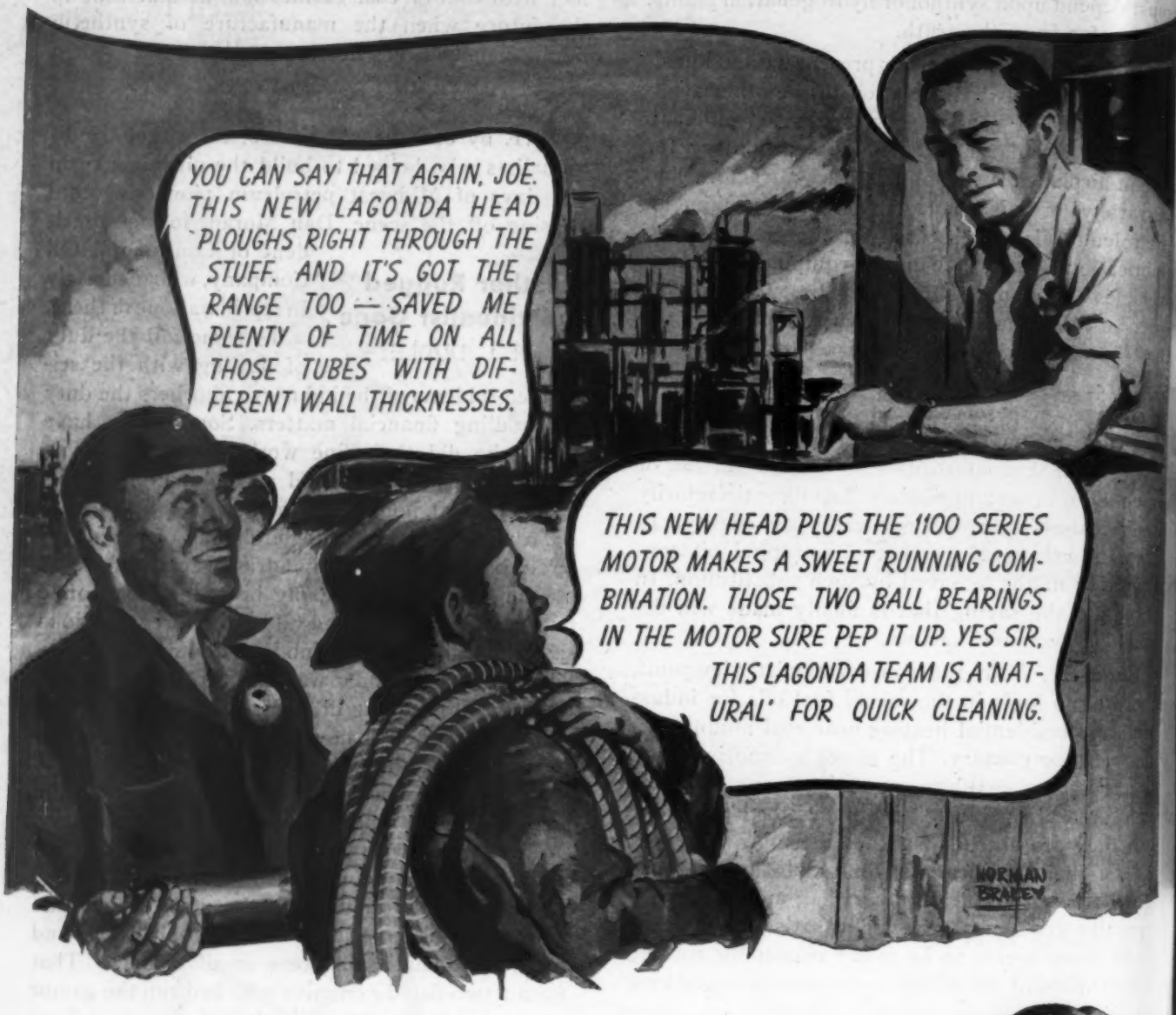
Few people who knew him were aware of the ambition of his innermost heart. A few years ago the writer sat with Dan Moran one evening, out under a western moon on his ranch. We exchanged confidential ambitions. Said he: "If I could do what I would most like to do, I would retire and teach mathematics in some small college." That from a two-fisted executive who had run the gamut of tough jobs in the oil business!

Further Use For Cheap Oxygen

THE direct flash smelting of nickel and copper sulphides with oxygen-enriched air and with commercial oxygen as a replacement for conventional reverberatory furnace smelting has been the subject of active research by a major mining organization. In the present stages of development, the processes have reached the pilot plant level and results have been most promising so that further work is proceeding.

It seems possible that still another use for cheap commercial oxygen may thus be found to add to the growing list that has followed the intensive development of this field since the synthol plants were initiated in this country.

BACK ALREADY? THOSE NEW LAGONDA SWING FRAME CUTTERHEADS MUST EAT THE COKE


YOU CAN SAY THAT AGAIN, JOE. THIS NEW LAGONDA HEAD PLOUGHS RIGHT THROUGH THE STUFF. AND IT'S GOT THE RANGE TOO — SAVED ME PLENTY OF TIME ON ALL THOSE TUBES WITH DIFFERENT WALL THICKNESSES.
THIS NEW HEAD PLUS THE 1100 SERIES MOTOR MAKES A SWEET RUNNING COMBINATION. THOSE TWO BALL BEARINGS IN THE MOTOR SURE PEP IT UP. YES SIR, THIS LAGONDA TEAM IS A 'NATURAL' FOR QUICK CLEANING.
NORMAN BRADLEY

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efferson Chemical Company

lant Layout

ON W. ALEXANDER, Associate Editor

JEFFERSON Chemical Company, Inc. formed in 1944 and jointly owned by The Texas Company and American Cyanamid Company, has completed and placed in operation the first section of a large hydrocarbon chemicals plant at Port Neches, Texas. For the most part, Jefferson utilized its own general engineering facilities in the design and layout of the various process units and accessory installations of this plant. Facilities of several major engineer-contractor firms were employed in the actual construction of the plant.

Especially interesting in the project are provisions which have been made to allow for future expansion. The field of hydrocarbon chemicals manufacture is

JEFFERSON Chemical Company, Inc.'s plant near Port Neches, Texas, is now in full commercial operation and its output of ethylene glycol and ethylene oxide, which are in extremely short supply, should aid materially in alleviating the situation. Best known for its use in permanent-type automobile anti-freeze, ethylene glycol is also used extensively in the manufacture of cellophane, resins, and low-freezing dynamite, in processing textiles and tobacco, and as an ingredient in brake fluids. Ethylene oxide is a chemical intermediate employed in making synthetic rubber, detergents, plastics, and various other products.

Utilized as raw material are refinery gases from The Texas Company's refinery at Port Arthur which are brought by pipe line to the Jefferson plant, 5 miles away. American Cyanamid Company has acquired about 900 acres adjoining the Jefferson installation, but it has not announced plans for its use.

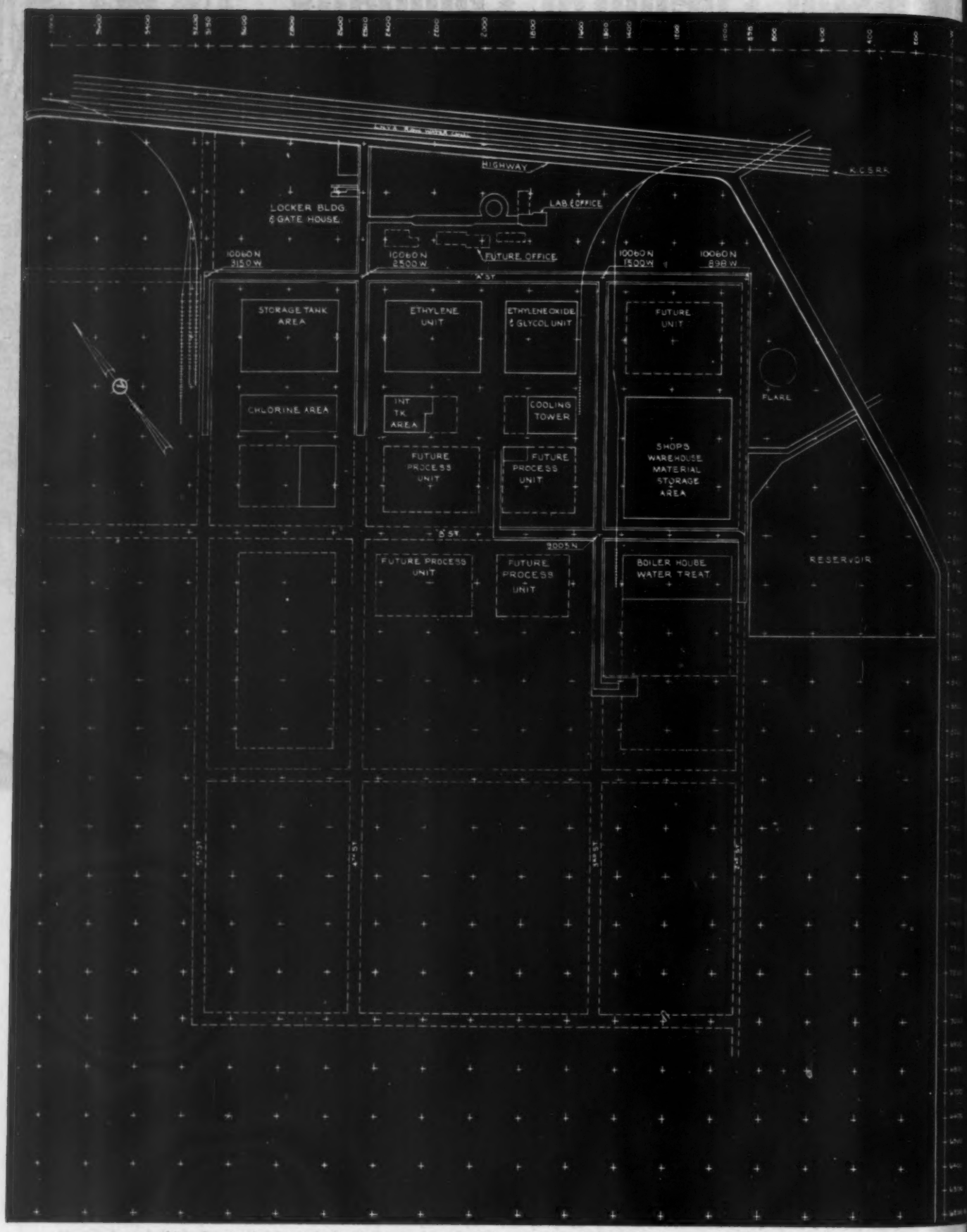
There are three process units in the plant: an ethylene unit, a combined ethylene oxide and ethylene glycol unit, and a unit to purify ethylene dichloride obtained as a co-product during the manufacture of ethylene oxide.

In the ethylene unit, the Texaco refinery gases are first treated with diethanolamine to remove carbon dioxide and hydrogen sulfide. This feed stock is then combined with the effluent from the cracking heaters, compressed, and separated in fractionating towers, some of which are operated under low temperatures requiring refrigeration for cooling and condensing. Propane and ethane are used as refrigerants.

The unit produces a purified ethylene stream, an aromatic distillate (high in aromatics), and a hydrocarbon polymer stream.

The ethylene oxide and ethylene glycol unit was designed after pilot plant work done by Jefferson's technical and research department at Port Arthur. Products of the unit are ethylene oxide, ethylene glycol, polyethylene glycol (largely diethylene glycol), and a crude ethylene dichloride. The latter is purified in a separate unit by drying and distillation, a mixture of higher chlorinated hydrocarbons being obtained along with the purified ethylene dichloride.

The initial layout and design of the present installation are especially interesting from an engineering viewpoint. Good layout of process industry plants can pay high dividends. In this article certain design considerations that influenced the layout of this latest addition to the industries ranks are discussed. It is believed that many of the ideas presented can profitably be applied in the design of any new hydrocarbon processing plant.



Map showing location of all units, storage areas, offices, etc., in relation to highway, and intra-plant roads.

rapidly increasing in size and importance, and management in planning this new plant was keenly aware that not only must each detail of the present installations fulfill the usual process, operating, and maintenance requirements, but in addition, the very maximum of ease and economy of installation must be provided for any future process units.

All too often, plants have been built in which too little consideration has been given to future expansion possibilities and requirements. As a result, many

large process industry plants now in operation have grown in a haphazard manner. Lack of sufficient thought during the early planning stages in many cases is now reflected in increased operating costs, and new construction of needed process facilities is sometimes faced with almost unsurmountable handicaps. Congested working areas present higher accident risks and result in increased insurance premiums. Such random planning may call for a major rearrangement of equipment or storage facilities, when new process units are to be built. Before the new equipment can be erected an extensive site clearing and preparation program may be required.

This new plant provides a sharp contrast to the random growth discussed above. A long range viewpoint toward future expansion possibilities was the keynote in the initial layout and design of the present installation.

Present process units, of course, have been designed to meet certain existing marketing oportunities. As new opportunities appear resulting from the company's research work, major expansion of chemical manufacturing facilities will be required. Provisions for this expansion are clearly a necessary feature of sound planning. This particular plant incorporates layout principles which are intended to afford a minimum of rearrangement and a maximum of construction convenience whenever future additions are made.

Land available for present and future requirements totals some 1100 acres and this tract is divided into two principal sections. One section, about 200 acres, fronts on the Neches River and will assure the plant the benefits of a deep water terminal for the movement of both finished products and new process equipment. The balance of the 1100 acres is located several hundred feet inland from the river. The two sections are connected by strip a of land which provides right-of-way for pipe lines and for any other necessary facilities between the plant, located inland on the large section, and the river front.

Night view of purification section of ethylene unit.

Fractionating towers on ethylene oxide and ethylene glycol unit. Note access platforms and tray removal trolley rails at top of towers.

Coordinate System Set Up

Located inland on the principal land section are the plant's process units, product storage, steam generation plant, water storage lake, water treatment plant, railroad loading rack for product shipment by tank car, maintenance shops and facilities, laboratories, administration, and other necessary buildings. This section has ben divided into areas, as indicated on the simplified plot plan, that are designed to accommodate the buildings and equipment of the present installation and to provide room for future additions. Administration buildings, laboratories, locker rooms, cafeteria, and gatehouse, are grouped at the north end of the tract at a location readily accessible to an all-weather highway. Space is provided in this area for future office buildings.

To establish a permanent and accurate basis for overall plant layout and for the location of individual items of equipment, a coordinate system was set up.

Base point of the coordinate system was arbitrarily established at the far south-east corner of the main tract. All horizontal and vertical measurements used within the plant originate at this point. The coordinate grid system was set up with lines parallel to the boundaries of the tract. As a matter of convenience, coordinates paralleling the short southwest boundary of the tract are designated as north coordinates and those paralleling the long southeast boundary are designed as west coordinates. Major coordinates were established at 200-foot intervals and a number of secondary benchmarks placed for convenient reference throughout the plant.

Monuments with coordinate and elevation data mark each corner of the various individual unit areas. This system provides each area with permanently located stations from which any installation can be

Compressors in the ethylene unit showing suction and discharge pipe. The aisle at left is typical of the provisions in the layout for ease of access for maintenance and fire protection.

definitely located and greatly facilitates the installation of new equipment and piping.

Open areas of 100-foot width are maintained between all process installations and the unit area boundaries. These clearances provide adequate space for any maintenance operation which may arise and are a prime safety factor, as they provide a minimum of 200 feet between adjoining process units and 100 feet between plant streets and process installations. This wide spacing greatly lessens process area fire hazard.

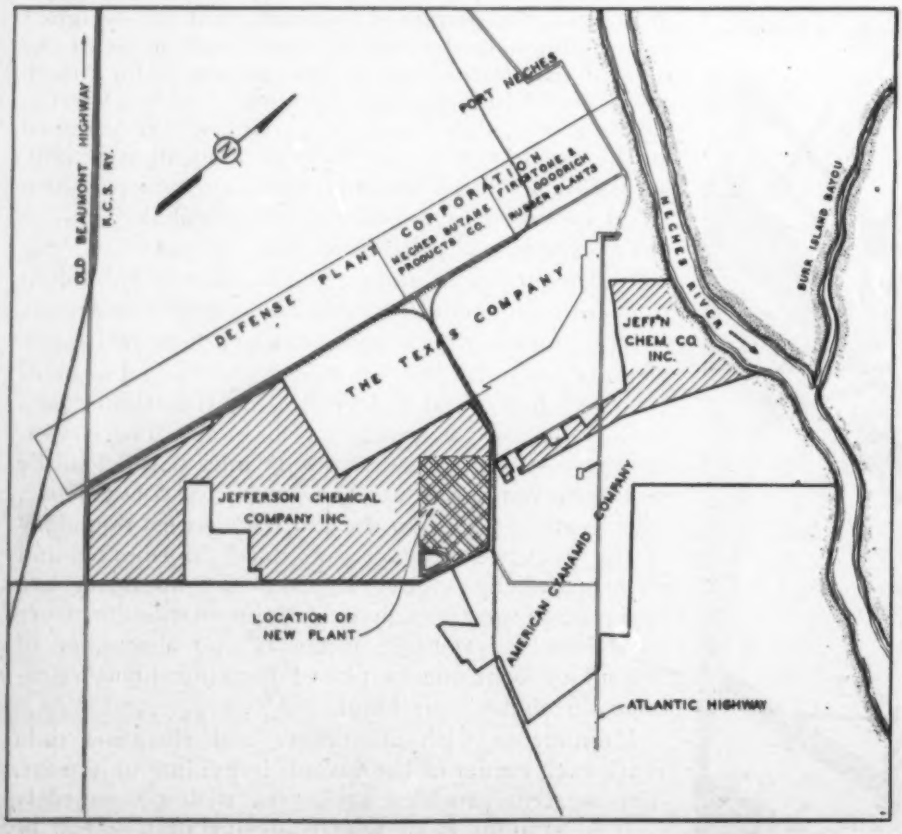
Plant streets have been laid out parallel to the coordinate system and serve not only to provide access but also as boundaries between maintenance, utility, processing, loading, and storage areas. The process area, for instance, is centrally placed between parallel streets which serve as east and west boundaries of a long rectangular strip. This strip provides ground space for the present process units and for future additions.

Future units, added as the occasion demands, are to be placed within the boundaries of the rectangular process area and in each instances will occupy a plot site adjacent to and immediately south of the existing process area.

A similar layout scheme has been adopted for the plant storage tank area and for the plant utility area.

The over-all result is that each new process unit that is added will be provided with an adequate and conveniently located storage area immediately to the west of the process area, and with open land immediately to the east for such additional plant maintenance and utility facilities as may be required. A railroad siding enters the plant near the northwest boundary corner and runs south along the west boundary of the plant storage tank area. This track, and a product loading rack that parallels the track, can be extended southward as new process units are added and thus will provide adequate loading facilities convenient to the product storage area.

A rectangular strip of land that runs along the east side of the plant site has been reserved for mainte-



Map showing location of Jefferson Chemical Company's new plant at Port Neches, Texas.

Combination office and laboratory. Penthouse in front contains air conditioning equipment for some of the laboratories and the air circulating and winter conditioning equipment for the whole building. Eventually the building will be used solely for a laboratory and was designed with this idea in mind.

nance shops, warehouses, equipment storage area, boiler houses, and water-treating installations.

The utilities, water, fuel gas, and electrical power, are purchased from local sources. Water for plant operation is stored in a 13½-acre reservoir adjacent to the water-treating plant. Main electrical power lines are overhead. Power is delivered throughout the plant by underground cables buried in red concrete for safety and to provide sure identification during future construction excavation.

Utilities required by the process units are supplied from this power plant-water treatment area through lines which run parallel to the main roads of the plant, along the sides of the roads dividing the process area from the utility area and from the storage area. Drainage ditches for the plant also parallel the roads.

Trolley Beams and Hoists Installation

Individual process units are compact but may grow in capacity somewhat without the development of undue congestion inside the process unit limits. Compressor groups, pump rows, and heat exchanger banks have been arranged to allow space for some additions to be made and to provide easy access.

Sufficient trolley beams and hoists are provided as permanent installations in process areas and strategically located to permit convenient handling of most equipment normally subject to maintenance or inspection operations. The removal and replacement of exchanger and reboiler tubes is facilitated by such trolley beam and hoist installations, and each tower is equipped with a permanent crane at top platform level.

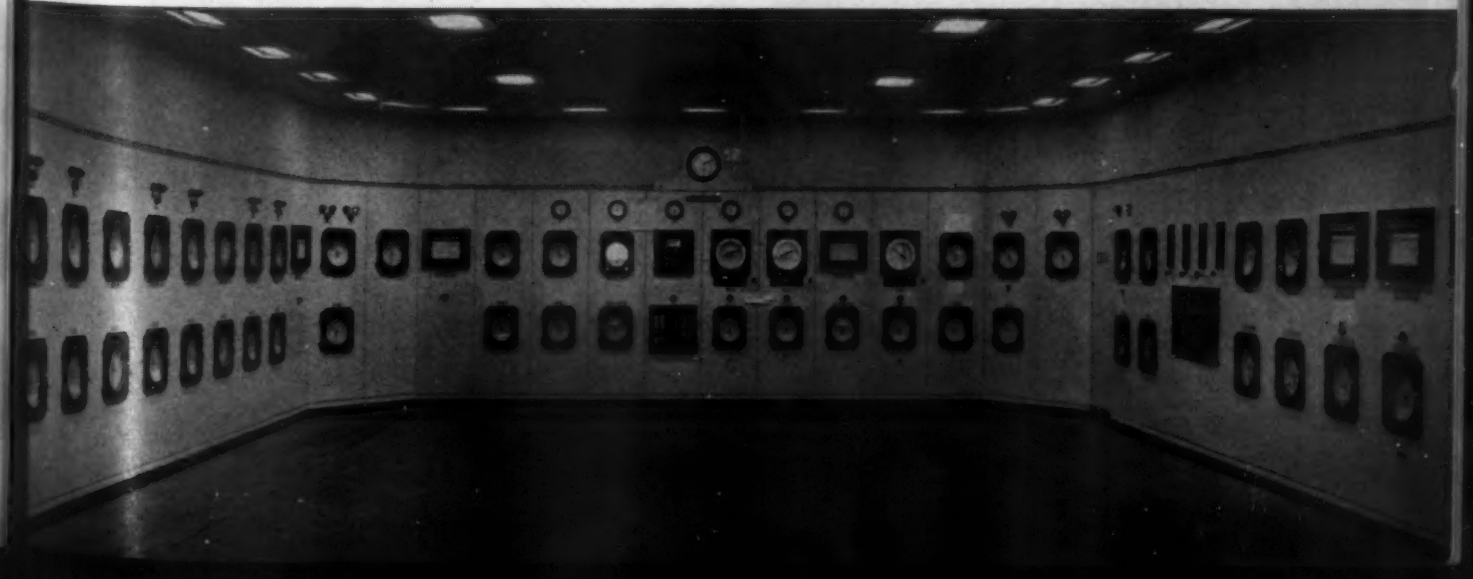
Process piping is carried overhead and in general is supported by chain hangers. Pipe alleys located in 100-foot "right-of-ways" are positioned through the process area to provide simple arrangement of piping. Access ways through the process unit areas are provided for trucks and other maintenance equipment, and piping, where necessary, is placed at sufficient elevation to allow clearance.

Fire protection installations consist of a fire protection water main which loops the present process area. Water is supplied by two pumps, one being driven by an electric motor and the other by a steam turbine, to minimize the possibility of a failure during an emergency. Another loop with additional pumps may be added to the present fire system to supply future plant expansion requirements. The fire pumps are located at the water-treating plant adjacent to the boundary between present plant installations and the area reserved for future process plant expansion, and this new loop will have approximately the same relative position with respect to the fire pumps as does the present loop.

Other fire protection installations include houses for the storing of fire hoses, foam hoppers, and chemicals used in fire fighting. Fire blankets and CO_2 type extinguishers are strategically located throughout the plant. Monitor fire nozzle stations, which will send a stream of water at any desired direction and angle, are located throughout the process area and are so spaced that a fire in any part of the area can be reached from several angles.

All process vessels pressure relief valves are connected to a waste gas flare which is 18 inches in diameter and 175 feet tall. The flare is located well away from the process units and in an area not considered hazardous. Materials vented to the flare stack flow first through a condensate tank having a water seal. Any liquids that may accumulate in the piping are accumulated here. Additional lines may be added to the condensate tank to accommodate future plant

The control room in the ethylene oxide and ethylene glycol unit has an acoustical ceiling, light buff-colored panels to minimize eye strain and an emergency exit (far end of the right-hand panel).



Six of the ten chlorine storage tanks. Piping at near end is a portion of the water spray system, controlled remotely, if it is necessary to cool the tanks. At far end is small horizontal surge tank connected into a run of the chlorine piping. This surge chamber is typical of many in the chlorine piping and is to take care of liquid expansion.

additions as at present, the flare installation load requirement is estimated to be one-third of the designed capacity. The flared gas is fired automatically.

The present steam generation system consists of three forced and induced draft boilers designed to maintain 625 psi. At present the system is maintained at 200 psi. which is adequate for present requirements of the plant. The steam generation system is completely under instrument control. To facilitate operation all controls including main steam and feed-water valves are located at floor level. To provide for anticipated expansion, line connections have been installed for additional boilers.

Water from the Neches River, due to the proximity of the Gulf of Mexico, has an objectionable saline content, and is not suitable for use in the plant. Water for plant and domestic use is purchased from the Lower Neches Valley Authority and is delivered to the 18-million gallon reservoir by a pipe line from an LNVA canal located near the plant site.

An extensive water treating system with continuous chemical feeders is employed to prepare water for plant use. Clay and alum, caustic, and zeolite are used, and both process and domestic water are chlorinated and filtered. The precipitators and clear well of the treating system are interchangeable. The present clear well can become a precipitator with a new clear well extension being added to the present system to increase the throughput. Adjacent space has been allocated for the duplication of the present system as the demand for process water increases with the proposed expansion of process facilities.

The laboratory building is entirely fire proof with fixtures such as benches, tables, cabinets, and shelves of metal. All rooms are sound-proofed with the metal wall sections filled with glass wool. The upper floor is devoted to office space, conference rooms, and library. Available at all bench work areas are hot and cold water, demineralized water, fuel gas, exhaust steam, compressed air and electricity. Partitions within the building are movable and are positioned in accordance with a modular system of layout. The size of work areas can thus be altered at will to suit the requirement of any specific work program. Utilities are provided through conduit panels located in the permanent exterior walls of the building, and are thus accessible to whatever areas may be arranged by interior partition changes.

As in the case of the plant itself, provision has been made for expansion of the laboratory facilities either by rearrangement of the present space or by addition of further wings to the present building. Provision has also been made for the future installation of equipment requiring more than eight to ten feet of head room, such as fractionating columns which would be required for plant quality control work.

As far as development work is concerned, this is carried out in small scale in a laboratory which the company operates in New York and in a research installation at Port Arthur, Texas. The latter also includes equipment for larger scale process development and pilot plant work, which is carried out for the company by its technical and research group.

As a result of careful planning and forethought, the new petrochemical plant may be considered a criterion in plant layout to provide for future expansion. Jefferson Chemical Company, Inc., has in this initial construction program established a precedent which undoubtedly will prove valuable to its operations in a rapidly growing industry. Flexibility and adaptability of process installations will play a major part in the long range success of plants built for this field.

Aerial view of plant recently completed by Jefferson Chemical Company, Inc., near Port Neches, Texas.
(All photos by Elwood Payne)

Applications of Thermodynamics to Hydrocarbon Processing

Part XI—DERIVATIONS FOR GRAPHICAL P-V-T CORRELATIONS

WAYNE C. EDMISTER*

WITH the foundation prepared in previous installments, the specific and generalized equations, charts and tables of thermodynamic properties for hydrocarbons may be developed. Starting with the fundamental equations stemming from the first and second laws of thermodynamics, and the compressibility factor and volume residual P-V-T correlations, the isothermal effects of pressure or volume changes on the various thermodynamic properties are obtained by a combination of analytical and graphical mathematics.

It has been said that mathematics is the language of thermodynamics. This is demonstrated in the present chapter where equations are derived for eight thermodynamic properties of fluids in terms of the compressibility factor Z (= PV/RT) and the volume residual α (= RT/P — V). The evaluation of the required derivatives and the integration of the functions are illustrated by equations and charts covering the mechanics of calculating the thermodynamic properties.

IN PARTS VIII and IX, the various P-V-T correlation methods were discussed and it was concluded that the generalized graphical correlations were the most practical for hydrocarbon systems because of the multicomponent nature of the fluids.

Two generalized graphs were shown to be preferred because of accuracy and convenience. These are correlations of the compressibility factor and the reduced volume residual as functions of reduced temperature and pressure. As shown in Part X, these generalized correlations are applied to pure hydrocarbon systems by the true critical conditions, and to hydrocarbon mixtures by the pseudo-critical conditions.

The compressibility is the ratio of the actual to the ideal gas volume and is denoted by the symbol Z, where

$$PV = ZRT \tag{180}$$

The volume residual is the difference between the ideal and actual gas volumes and is denoted by α, where

$$\alpha = \frac{RT}{P} - V \tag{183}$$

These two equations, which were presented and discussed in Part IX, may be combined to eliminate either P or V, but not both, to give equations relating Z and α. These equations are

$$\alpha = \frac{RT}{P}(1 - Z) \tag{204}$$

and

$$Z = \frac{V}{V + \alpha} \tag{205}$$

Equations 204 and 205 will be used to check equations using α with those using Z.

Equations for the specific heat, Joule-Thomson coefficient, entropy, energy and enthalpy will be developed from the fundamental equations and the Z and α correlations separately, thus giving two alternate methods of evaluating each thermodynamic property. An equation for the activity coefficient in terms of α will also be developed.

For some properties the Z equation is more convenient, while for other properties the α equation is more convenient. This will be shown by the equations derived in this chapter. For most cases, the choice between the Z and α equation is a matter of relative accuracy. Or, it is a choice between working with differences or ratios of two numbers. Near the critical, it is better to work with residuals. At low pressures and/or high temperatures where the deviations from ideal gas law are small, the Z correlation is satisfactory.

The derivatives for these equations may be found graphically in a manner illustrated. Likewise, the integrations may be performed graphically.

In evaluating these equations, it will be convenient to work in reduced units so as to develop relations that are generally applicable. Equations will first be derived in absolute rather than reduced units and then converted to reduced units by substituting for P, T, V, and α their equivalents

$$P = P_c P_r$$
$$T = T_c T_r$$
$$V = V_c V_r$$
$$\alpha = \alpha_c \alpha_r$$

The critical conditions, P_c, T_c, V_c, and α_c, are the true critical values for pure components and the pseudo-critical for mixtures.

For derivatives, this substitution is illustrated by the following:

$$\left(\frac{\delta\alpha}{\delta T}\right)_P = \frac{\alpha_c}{T_c}\left(\frac{\delta\alpha_r}{\delta T_r}\right)_{Pr} \tag{206}$$

$$\left(\frac{\delta^2\alpha}{\delta T^2}\right)_P = \left[\frac{\delta\left(\frac{\delta\alpha}{\delta T}\right)_P}{\delta T}\right]_P = \left[\frac{\frac{\alpha_c}{T_c}\,\delta\left(\frac{\delta\alpha_r}{\delta T_r}\right)_{Pr}}{T_c\,\delta T_r}\right]_{Pr} = \frac{\alpha_c}{T_c^2}\left(\frac{\delta^2\alpha_r}{\delta T_r^2}\right)_{Pr} \tag{207}$$

$$\left(\frac{\delta Z}{\delta P}\right)_T = \frac{1}{P_c}\left(\frac{\delta Z}{\delta P_r}\right)_{Tr} \tag{208}$$

$$dP = P_c\,dP_r \tag{209}$$

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From these four examples, it can be seen that the substitutions are made in the same way for derivatives as for the original variables. The second derivative substitution is not as simple as the others but is straightforward if handled by the steps shown in equation 207.

Fundamental Equations

The following equations, which are based on the first and second laws of thermodynamics, are the starting points for the derivations developed in this installment. Most of these fundamental equations, but not all of them, were derived in Part III. Those not previously derived in this series may be developed by the same procedure shown, or they may be found from any of the thermodynamics texts.

Specific Heats—There are three specific heat equations of interest, namely:

$$\left(\frac{\delta C_v}{\delta V}\right)_T = T\left(\frac{\delta^2 P}{\delta T^2}\right)_v \qquad (70)$$

$$\left(\frac{\delta C_p}{\delta P}\right)_T = -T\left(\frac{\delta^2 V}{\delta T^2}\right)_p \qquad (72)$$

$$C_p - C_v = -T\,\frac{\left(\frac{\delta V}{\delta T}\right)_p^2}{\left(\frac{\delta V}{\delta P}\right)_T} \qquad (74)$$

Equation 70 will be of interest where the independent variables are V and T, as would be the case in an explicit-in-pressure equation of state and the internal energy equation. Equations 72 and 74 will be adequate for all of the work that follows in this series.

Joule-Thomson Coefficient—The equation for the Joule-Thomson coefficient involves the specific heat and a portion of the enthalpy equation.

$$\mu = \left(\frac{\delta T}{\delta P}\right)_H = -\frac{\left(\frac{\delta H}{\delta P}\right)_T}{C_p} = \frac{T\left(\frac{\delta V}{\delta T}\right)_p - V}{C_p} \qquad (66)$$

Each one of the terms in equation 66 are point values. No integration is involved in finding the Joule-Thomson coefficient.

Entropy—Two equations for the entropy will be included, one for P and T as independent variable and one for V and T as independent variables:

$$dS = \frac{C_p}{T}\,dT - \left(\frac{\delta V}{\delta T}\right)_p dP \qquad (68)$$

$$dS = \frac{C_v}{T}\,dT + \left(\frac{\delta P}{\delta T}\right)_v dV \qquad (68A)$$

These two entropy equations employ different heat capacities for calculating the effect of temperature on the entropy. In equation 68, the heat capacity, C_p, at constant pressure is generally taken at the ideal gas state, or at a pressure so low that pressure has no effect on heat capacity. As will be shown later, this is essentially zero pressure but not quite because of the mathematics of integrating equation 68. The reference volume for equation 68A is of only academic interest as far as these articles are concerned.

Internal Energy—The equation for the internal energy employs V and T as the independent variables.

$$dE = C_v dT + \left[\, T\left(\frac{\delta P}{\delta T}\right)_v - P \,\right] dV \qquad (56)$$

Equation 56 would be used with equation 68A to compute E and S values. Note the similarity of the terms. If an equation of state forced the use of V and T as the independent variables in preparing tables or charts of enthalpies and entropies, equations 56 and 68A could be used and the enthalpy found from

$$H = E + PV$$

With such a system in V and T as independent variables, the pressure could be found easily from the equation of state, thus permitting putting the final charts or tables of entropy and enthalpy in terms of P and T.

Enthalpy—The fundamental equation for this most useful thermodynamic property is

$$dH = C_p\,dT - \left[\, T\left(\frac{\delta V}{\delta T}\right)_p - V \,\right] dP \qquad (65)$$

In this equation C_p should be taken at zero pressure so as to simplify the integration for the isothermal effect of pressure, which is

$$\left(\frac{\delta H}{\delta P}\right)_p = \left[\, V - T\left(\frac{\delta V}{\delta T}\right)_p \,\right] \qquad (65A)$$

The enthalpy at zero pressure is higher than the enthalpy at any higher pressure. This makes the $[V - T\,(\delta V/\delta T)_P]$ term of equation 65A negative. This term was written of opposite sign in equation 65.

It is of interest to compare equations 56 and 65 and note their analogies.

Required Derivatives

The derivatives required in evaluating the above fundamental equations are tabulated below:

Independent Variables	First Derivative	Second Derivative
P and T	$\left(\frac{\delta V}{\delta T}\right)_P$	$\left(\frac{\delta^2 V}{\delta T^2}\right)_P$
P and T	$\left(\frac{\delta V}{\delta P}\right)_T$	.....
V and T	$\left(\frac{\delta P}{\delta T}\right)_V$	$\left(\frac{\delta^2 P}{\delta T^2}\right)_V$

Each of these derivatives will be found in terms of the Z and the α factors, as defined by equations 180 and 183, and then checked for consistency by means of equations 204 and 205.

In obtaining these derivatives, it is assumed that the Z and α factors are unique functions of the independent variables, P and T, or V and T, as the case may be. This permits differentiating equations 180 and 183 and getting the desired derivatives as functions of the derivatives of Z or α.

Each derivative will be handled by both methods and then checked before taking up the next.

$(\delta V/\delta T)_P$—The first derivative of volume with respect to temperature, pressure constant, is found by differentiating equations 180 and 183, giving

$$\left(\frac{\delta V}{\delta T}\right)_P = \frac{ZR}{P} + \frac{RT}{P}\left(\frac{\delta Z}{\delta T}\right)_P \qquad (210)$$

and

$$\left(\frac{\delta V}{\delta T}\right)_P = \frac{R}{P} - \left(\frac{\delta \alpha}{\delta T}\right)_P \qquad (211)$$

These two equations, which give the same derivative in

terms of different P-V-T correlations, are consistent as can be shown by differentiating equation 204 to obtain

$$\left(\frac{\delta\alpha}{\delta T}\right)_P = \frac{R}{P} - \frac{ZR}{P} - \frac{RT}{P}\left(\frac{\delta Z}{\delta T}\right)_P \quad (212)$$

This relation between $\left(\frac{\delta\alpha}{\delta T}\right)_P$ and $\left(\frac{\delta Z}{\delta T}\right)_P$ is identical to the expression obtained by combining equations 210 and 211, thus proving the consistency of equations 210 and 211.

$(\delta^2V/\delta T^2)_P$ —The second derivative of volume with respect to temperature, pressure constant is found by differentiating equations 210 and 211, giving

$$\left(\frac{\delta^2 V}{\delta T^2}\right)_P = \frac{2R}{P}\left(\frac{\delta Z}{\delta T}\right)_P + \frac{RT}{P}\left(\frac{\delta^2 Z}{\delta T^2}\right)_P \quad (213)$$

and

$$\left(\frac{\delta^2 V}{\delta T^2}\right)_P = -\left(\frac{\delta^2\alpha}{\delta T^2}\right)_P \quad (214)$$

These two equations, which give the same derivative in terms of different P-V-T correlations, are consistent as can be shown by differentiating equation 212 to obtain

$$\left(\frac{\delta^2\alpha}{\delta T^2}\right)_P = -\frac{2R}{P}\left(\frac{\delta Z}{\delta T}\right)_P - \frac{RT}{P}\left(\frac{\delta^2 Z}{\delta T^2}\right)_P \quad (215)$$

This relation between $(\delta^2\alpha/\delta T^2)_P$ and $(\delta^2 Z/\delta T^2)_P$ is identical to the expression obtained by combining equations 213 and 214, thus proving the consistency of equations 213 and 214.

$(\delta V/\delta P)_T$ —The first derivative of volume with respect to pressure, temperature constant, is obtained by differentiating equations 180 and 183, giving

$$\left(\frac{\delta V}{\delta P}\right)_T = \frac{RT}{P}\left(\frac{\delta Z}{\delta P}\right)_T - \frac{ZRT}{P^2} \quad (216)$$

and

$$\left(\frac{\delta V}{\delta P}\right)_T = -\frac{RT}{P^2} - \left(\frac{\delta\alpha}{\delta P}\right)_T \quad (217)$$

These two equations, which give the same derivative in terms of different P-V-T correlations, are consistent and can be seen by differentiating equation 204 to obtain

$$\left(\frac{\delta\alpha}{\delta P}\right)_T = -\frac{RT}{P^2} + \frac{ZRT}{P^2} - \frac{RT}{P}\left(\frac{\delta Z}{\delta P}\right)_T \quad (218)$$

This relation between $(\delta\alpha/\delta P)_T$ and $(\delta Z/\delta P)_T$ is identical to the expression obtained by combining equations 216 and 217, thus proving the consistency of equations 216 and 217.

$(\delta P/\delta T)_V$ —The first derivative of pressure with respect to temperature, volume constant, is obtained by differentiating equations 180 and 183, giving

$$\left(\frac{\delta P}{\delta T}\right)_V = \frac{ZR}{V} + \frac{RT}{V}\left(\frac{\delta Z}{\delta T}\right)_V \quad (219)$$

and

$$\left(\frac{\delta P}{\delta T}\right)_V = \frac{R}{(V+\alpha)} - \frac{RT}{(V+\alpha)^2}\left(\frac{\delta\alpha}{\delta T}\right)_V \quad (220)$$

These two equations, which give the same derivatives in terms of different P-V-T correlations, are consistent as can be shown by differentiating equation 205 to give

$$\left(\frac{\delta Z}{\delta T}\right)_V = -\frac{V}{(V+\alpha)^2}\left(\frac{\delta\alpha}{\delta T}\right)_V \quad (221)$$

This relation between $(\delta Z/\delta T)_V$ and $(\delta\alpha/\delta T)_V$ is identical to the expression obtained by combining equations 219 and 220, while substituting for the Z in equation 219 its equivalent from equation 205, thus proving the consistency of equations 219 and 220.

$(\delta^2P/\delta T^2)_V$—The second derivative of pressure with respect to temperature, volume constant, is obtained by differentiating equations 219 and 220, giving

$$\left(\frac{\delta^2 P}{\delta T^2}\right)_V = \frac{2R}{V}\left(\frac{\delta Z}{\delta T}\right)_V + \frac{RT}{V}\left(\frac{\delta^2 Z}{\delta T^2}\right)_V \quad (222)$$

and

$$\left(\frac{\delta^2 P}{\delta T^2}\right)_V = \frac{2RT}{(V+\alpha)^3}\left(\frac{\delta^2\alpha}{\delta T^2}\right)_V - \frac{2R}{(V+\alpha)^2}\left(\frac{\delta\alpha}{\delta T}\right)_V \quad (223)$$

These two equations, which give the same derivative in terms of different P-V-T correlations, are consistent as can be seen by differentiating equation 221 to obtain

$$\left(\frac{\delta^2 Z}{\delta T^2}\right)_V = \frac{2V}{(V+\alpha)^3}\left(\frac{\delta^2\alpha}{\delta T^2}\right)_V \quad (224)$$

The relation between $(\delta^2 Z/\delta T^2)_V$ and $(\delta^2\alpha/\delta T^2)_V$ may be obtained by combining equations 222 and 223, while substituting for the $(\delta Z/\delta T)_V$ term of equation 222 its equivalent from equation 221, thus proving the consistency of equations 222 and 223.

The derivatives obtained above are summarized in Table 14 shown below.

Derived Equations

The next step in the development of thermodynamic

TABLE 14
Summary of Expressions for Derivatives

Derivative	P-V-T CORRELATION BASIS	
	Compressibility Factor	Volume Residual
$\left(\frac{\delta V}{\delta T}\right)_P =$	$\frac{ZR}{P} + \frac{RT}{P}\left(\frac{\delta Z}{\delta T}\right)_P$	$\frac{R}{P} - \left(\frac{\delta\alpha}{\delta T}\right)_P$
$\left(\frac{\delta^2 V}{\delta T^2}\right)_P =$	$\frac{2R}{P}\left(\frac{\delta Z}{\delta T}\right)_P + \frac{RT}{P}\left(\frac{\delta^2 Z}{\delta T^2}\right)_P$	$-\left(\frac{\delta^2\alpha}{\delta T^2}\right)_P$
$\left(\frac{\delta V}{\delta P}\right)_T =$	$\frac{RT}{P}\left(\frac{\delta Z}{\delta P}\right)_T - \frac{ZRT}{P^2}$	$-\frac{RT}{P^2} - \left(\frac{\delta\alpha}{\delta P}\right)_T$
$\left(\frac{\delta P}{\delta T}\right)_V =$	$\frac{ZR}{V} + \frac{RT}{V}\left(\frac{\delta Z}{\delta T}\right)_V$	$\frac{R}{V+\alpha} - \frac{RT}{(V+\alpha)^2}\left(\frac{\delta\alpha}{\delta T}\right)_V$
$\left(\frac{\delta^2 P}{\delta T^2}\right)_V =$	$\frac{2R}{V}\left(\frac{\delta Z}{\delta T}\right)_V + \frac{RT}{V}\left(\frac{\delta^2 Z}{\delta T^2}\right)_V$	$\frac{2RT}{(V+\alpha)^3}\left(\frac{\delta^2\alpha}{\delta T^2}\right)_V - \frac{2R}{(V+\alpha)^2}\left(\frac{\delta\alpha}{\delta T}\right)_V$

equations is to substitute these derivatives into the fundamental equations. Each function requires different handling. The equations derived below require calorimetric heat capacity data to give the effect of temperature on the property involved.

The solution of these equations also requires evaluating the derivatives from the Z and α plots. This will be discussed next after the development of the equations.

Specific Heats—Combining equations 70 with 222 and 223 gives

$$\left(\frac{\delta C_v}{\delta V}\right)_T = \frac{2RT}{V}\left(\frac{\delta Z}{\delta T}\right)_v + \frac{RT^2}{V}\left(\frac{\delta^2 Z}{\delta T^2}\right)_v \quad (225)$$

and

$$\left(\frac{\delta C_v}{\delta V}\right)_T = \frac{2RT^2}{(V+\alpha)^2}\left(\frac{\delta^2 \alpha}{\delta T^2}\right)_v - \frac{2RT}{(V+\alpha)^2}\left(\frac{\delta \alpha}{\delta T}\right)_v \quad (226)$$

Equations 225 and 226 give the isothermal effect of volume on the specific heat at constant volume. In order to find C_v at any condition, these equations are integrated and the results added to the C_v value at a reference volume.

Combining equations 72 with 213 and 214 gives

$$\left(\frac{\delta C_p}{\delta P}\right)_T = -\frac{2RT}{P}\left(\frac{\delta Z}{\delta T}\right)_p - \frac{RT^2}{P}\left(\frac{\delta^2 Z}{\delta T^2}\right)_p \quad (227)$$

and

$$\left(\frac{\delta C_p}{\delta P}\right)_T = T\left(\frac{\delta^2 \alpha}{\delta T^2}\right)_p \quad (228)$$

Equations 227 and 228 give the isothermal effect of pressure on the specific heat at constant pressure. To find the value of C_p at any condition, equations 227 or 228 must be integrated with the ideal gas (zero pressure) state heat capacities determining the effect of temperature on C_p. Ideal gas specific heat is designated as C_p°, which is a function of temperature for each hydrocarbon.

The difference between the specific heats at constant pressure and constant volume is found by combining equation 74 with equations 210 and 216 and with 211 and 217, giving

$$C_p - C_v = T\frac{\left[\frac{ZR}{P} + \frac{RT}{P}\left(\frac{\delta Z}{\delta T}\right)_p\right]^2}{\left[\frac{ZRT}{P^2} - \frac{RT}{P}\left(\frac{\delta Z}{\delta P}\right)_T\right]} \quad (229)$$

and

$$C_p - C_v = T\frac{\left[\frac{R}{P} - \left(\frac{\delta \alpha}{\delta T}\right)_p\right]^2}{\left[\frac{RT}{P^2} + \left(\frac{\delta \alpha}{\delta P}\right)_T\right]} \quad (230)$$

These equations give $C_p - C_v$ for actual gases at any condition of P and T.

Joule-Thomson Coefficient—This important thermodynamic property can be expressed in terms of the P-V-T correlations and the heat capacity. The equations are found by combining equation 66 with equations 180 and 210 or with equations 183 and 211, giving

$$\mu = \frac{\frac{RT^2}{P}\left(\frac{\delta Z}{\delta T}\right)_p}{C_p} \quad (231)$$

and

$$\mu = \frac{\left[\alpha - T\left(\frac{\delta \alpha}{\delta T}\right)_p\right]}{C_p} \quad (232)$$

In these two equations for the Joule-Thomson coefficient, the terms are evaluated at the P and T conditions involved. Thus C_p must be found as $C_p^\circ + \Delta C_p$, where C_p° and ΔC_p are the ideal gas heat capacity and the isothermal pressure correction to heat capacity, both at the temperature condition for which μ is being calculated.

Entropy—Four entropy equations will be found, two with V and T as independent variables and two with P and T as independent variables. With each pair of variables, entropy equations based on both Z and α correlation will be derived.

Combining equation 68 with equations 210 and 211 gives the following for P and T as the independent variables

$$dS = \frac{C_p}{T}dT - \frac{R}{P}\left[Z + T\left(\frac{\delta Z}{\delta T}\right)_p\right]dP \quad (233)$$

and

$$dS = \frac{C_p}{T}dT - \frac{R}{P}dP + \left(\frac{\delta \alpha}{\delta T}\right)_p dP \quad (234)$$

These two equations give the entropy as a differential equation with one term that must be inegrated with temperature and two that must be integrated with pressure.

In equation 233, the pressure terms are grouped together because they depend upon the Z correlation. In equation 234, the pressure terms are separate because the $\frac{R}{P}dP$ term is independent of the α correlation. In equation 234, the last term, $(\delta\alpha/\delta T)_P\, dP$, gives the effect of deviations from ideal gas laws. In other words, the entropy of an ideal gas is given by

$$dS = \frac{C_p}{T}dT - \frac{R}{P}dP \quad (101)^*$$

This is the equation used in Part IV in computing entropies of a perfect gas. The distinction between an actual and an ideal gas is not as clear cut in equation 233. For this reason equation 234 is preferred.

Combining equation 68A with equations 219 and 220 gives the following expressions for the entropy as a function of Z and α for V and T independent variables.

$$dS = \frac{C_v}{T}dT + \frac{R}{V}\left[Z + T\left(\frac{\delta Z}{\delta T}\right)_v\right]dV \quad (235)$$

and

$$dS = \frac{C_v}{T}dT + \frac{R}{(V+\alpha)}dV - \frac{R}{(V+\alpha)^2}\left(\frac{\delta \alpha}{\delta T}\right)_v dV \quad (236)$$

Equation 235 is analogous to equation 233. Of these four equations for S, equation 234 is the most convenient. The term $(V + \alpha)$ in equation 236 is the ideal gas volume, which makes equation 236 analogous to equation 234.

Internal Energy—Combining equation 56 with equation 219 and with equation 220, using equations 180 and 183 to eliminate the P term in equation 56, gives the following equation for the internal energy:

$$dE = C_v dT + \frac{RT^2}{V}\left(\frac{\delta Z}{\delta T}\right)_v dV \quad (237)$$

and

$$dE = C_v dT - \frac{RT^2}{(V+\alpha)^2}\left(\frac{\delta \alpha}{\delta T}\right)_v dV \quad (238)$$

These internal energy equations are simple and easy to integrate.

* Equations marked thus apply to perfect gases.

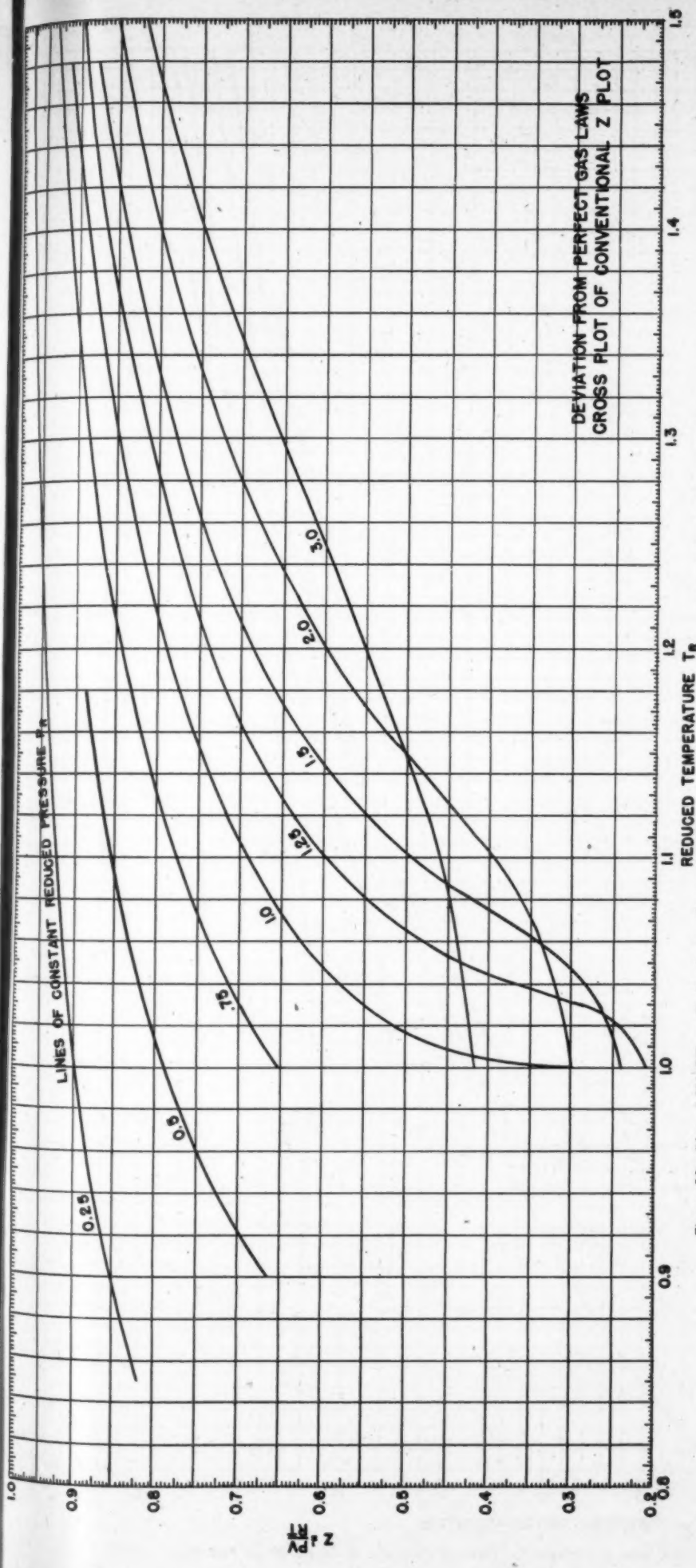


Figure 28—Plot of PV/RT vs. T_r for lines of constant P_r. This is a cross plot of conventional Z plot (Figure 19 in Part IX).

Enthalpy—The equations for the enthalpy are found by combining equation 65 with equations 210 and 211, using equations 180 and 183 to replace the V term in equation 65. This gives the following two useful equations for the enthalpy.

$$dH = C_p dT - \frac{RT^2}{P}\left(\frac{\delta Z}{\delta T}\right)_P dP \qquad (239)$$

and

$$dH = C_p dT - \left[\alpha - T\left(\frac{\delta \alpha}{\delta T}\right)_P\right] dP \qquad (240)$$

It will be noted that the coefficients of dP are the numerators of the Joule - Thomson coefficient expressions, equations 231 and 232.

The $(V + \alpha)$ term in equations 226, 236 and 238 could be replaced by its equivalent RT/P, but this would introduce P into equations having V and T as independent variables. This would be undesirable. For these functions, with V and T as independent variables, a more satisfactory volume residual P-V-T correlation would be the Δ residual given by equations 187, 188 and 189 of Part IX.

Reduced Form of Derived Equations

All of the equations derived in the above section, i.e., equations 225 through 240, are in terms of ordinary absolute temperatures, pressures and volumes and not reduced conditions. Since the α and Z correlations employ reduced units (see Figures 19 and 20 of Part IX) it is necessary to put these equations in the reduced form. This is done by using the relations given in the introduction of this chapter.

The results of this generalization are summarized in Table 15 where equations are given for both Z and α_r correlations of P-V-T data. From an examination of these equations, it can be seen that the equations based on the Z correlation are more convenient when the independent variables are V and T. Also the equations employing α_r are more convenient when the independent variables are P and T.

Equation 225A is the most convenient for the isothermal effect of volume on C_v. The corresponding equation for C_v in terms of α_r is not included because it is too complex. Equation 228A is the most convenient for the isothermal effect of pressure on C_p. Equation 229A is the

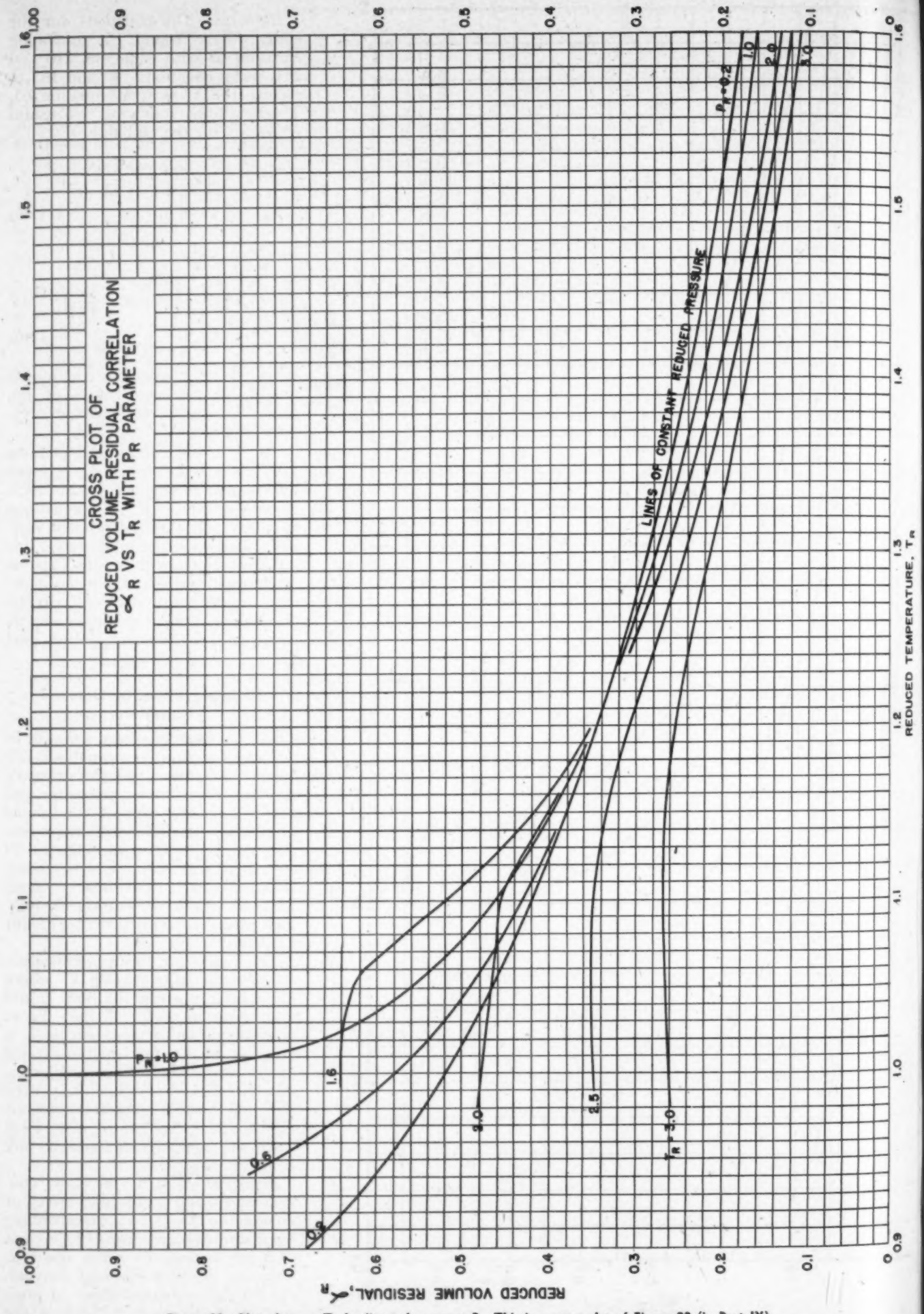


Figure 29—Plot of α_r vs. T_r for lines of constant P_r. This is a cross plot of Figure 20 (in Part IX).

TABLE 15
Generalized Thermodynamic Equations

Function	Compressibility Factor Equations		Reduced Volume Residual Equation	
$\left(\frac{\partial C_v}{\partial V_r}\right)_{T_r}$ =	$2R\left(\frac{T_r}{V_r}\right)\left[\left(\frac{\partial Z}{\partial T_r}\right)_{V_r}+\frac{T_r}{2}\left(\frac{\partial^2 Z}{\partial T_r^2}\right)_{V_r}\right]$	(225A)		
$\left(\frac{\partial C_p}{\partial P_r}\right)_{T_r}$ =	$-2R\left(\frac{T_r}{P_r}\right)\left[\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}+\frac{T_r}{2}\left(\frac{\partial^2 Z}{\partial T_r^2}\right)_{P_r}\right]$	(227A)	$\frac{P_c\alpha_c}{T_c}T_r\left(\frac{\partial^2\alpha_r}{\partial T_r^2}\right)_{P_r}$	(228A)
$C_p - C_v$ =	$R\frac{\left[Z+T_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}\right]^2}{\left[Z-P_r\left(\frac{\partial Z}{\partial P_r}\right)_{T_r}\right]}$	(229A)	$T_r\frac{\left[\frac{R}{P_r}-\frac{P_c\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]^2}{\left[\frac{RT_r}{P_r^2}+\frac{P_c\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial P_r}\right)_{T_r}\right]}$	(230A)
μ =	$\frac{\left(\frac{RT_c}{P_c}\right)\frac{T_r^2}{P_r}\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}}{C_p}$	(231A)	$\frac{\alpha_c\left[\alpha_r-T_r\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]}{C_p}$	(232A)
dS =	$\frac{C_p}{T}dT-\frac{R}{P_r}\left[Z+T_r\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}\right]dP_r$	(233A)	$\frac{C_p}{T}dT-\frac{R}{P}dP+\frac{P_c\alpha_c}{T_c}\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}dP_r$	(234A)
dS =	$\frac{C_v}{T}dT+\frac{R}{V_r}\left[Z+T_r\left(\frac{\partial Z}{\partial T_r}\right)_{V_r}\right]dV_r$	(235A)		
dE =	$C_v\,dT+RT_c\frac{T_r^2}{V_r}\left(\frac{\partial Z}{\partial T_r}\right)_{V_r}dV_r$	(237A)		
dH =	$C_p\,dT-RT_c\frac{T_r^2}{P_r}\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}dP_r$	(239A)	$C_pdT-P_c\alpha_c\left[\alpha_r-T_r\left(\frac{\partial\alpha_r}{\partial T_r}\right)_{P_r}\right]dP_r$	(240A)
$\ln\frac{f}{P}$ =			$-\frac{P_c\alpha_c}{RT_c}\frac{1}{T_r}\int_0^{P_r}\alpha_r\,dP_r$	(244A)

most convenient and significant for the difference in specific heats. It is significant because $C_p - C_v = R$ for an ideal gas, making the term to the right of R in equation 229 A the correction for the deviation from the perfect gas law.

Equation 234A is the most convenient and logical for the entropy because of the clear cut distinction between ideal and actual gases. If the independent variables for entropy are to be V and T, equation 235A is the most convenient. The corresponding equation for dS in terms of α_r with V and T as independent variables is omitted because it is too complex to be useful.

Equation 237A is the most convenient for the internal energy. Here, likewise, the corresponding equation for dE is omitted because it is too complex to be useful. For the enthalpy both equations 239A and 240A are convenient so the choice between the two should be made for other reasons. The same applies to the Joule-Thomson coefficient equation.

In preparing charts and tables of generalized thermodynamic properties, time would be saved by using the equations for one or the other P-V-T correlations, but not mixing them. In other words, Joule-Thomson coefficient, enthalpy and entropy should all be computed by the same family of equations, thus permitting the use of the same derivatives. In subsequent developments discussed in this series, the α_r basis will be used for specific heats, entropy, and enthalpy. The Z correlation will be used in a few special cases.

The units of the constants in these equations determine the units of the resulting thermodynamic properties. The group of constants, $P_c\alpha_c/T_c$, which appears in equations 228A, 230A, and 234A, is defined as K_2 for convenience. Values of K_2 were given in Table 13 of Part VII for over 30 hydrocarbons. The units of K_2 in Table 13 were Btu/lb. mol-°R or g-cal/gram mol-°K. The units of K_2 could be on a weight rather than a molal basis.

The group of constants, $P_c\alpha_c$, which appears in equation 240A, is defined as K_3. Values of K_3 were likewise given in Table 13, where the units were Btu/lb.

Fugacity

The fugacity and activity coefficient will be used in a future chapter dealing with equilibrium. In preparation for this, the fugacity will be defined and formulated at this point.

The free energy F is used in equilibrium calculations. Equation 84 in Part III states

$$\left(\frac{\partial F}{\partial P}\right)_T = V \qquad (84)$$

For a perfect gas, V is replaced by RT/P and equation 84 integrated to give

$$(\Delta F)_T = F_2 - F_1 = \int_1^2 V\,dP = RT\ln\frac{P_2}{P_1} \qquad (241)^*$$

Equation 241 is for a perfect gas. The fugacity is defined as a replacement for P in equation 241 to fit the P-V-T data of actual gases so that

$$RT\ln\frac{f_2}{f_1} = \int_{P_1}^{P_2} V\,dp \qquad (242)$$

Repacing V by $(RT/P - \alpha)$ gives

$$RT\ln\frac{f_2}{f_1} = RT\ln\frac{P_2}{P_1} - \int_{P_1}^{P_2}\alpha\,dP \qquad (243)$$

If the initial or reference pressure, P_1, is taken as zero, at which point $f_1 = P_1 \left(\text{or } \lim_{P \to o} \frac{f}{P} = 1 \right)$, equation 243 becomes

$$RT \ln \frac{f}{P} = - \int_o^P \alpha dP \qquad (244)$$

This equation is given by Lewis and Randall, by Dodge, and many others.

In terms of reduced units, equation 244 becomes

$$\ln \frac{f}{P} = - \frac{P_c \alpha_c}{RT_c} \frac{1}{T_r} \int_o^{P_r} \alpha_r dP_r \qquad (244A)$$

The ratio of fugacity to pressure is called the "activity coefficient" and is not to be confused with the activity, which is f/f°, where both f and f° are at the same temperature but f° is the fugacity at the standard pressure state. Equation 243 gives the activity.

By comparing equations 243 and 244, it can be seen that the activity coefficient is the ratio of the activity of an actual gas to the activity of an ideal gas.

Equation 244A is the preferred expression for the activity coefficient. An equation in terms of Z is not required. The constant group $P_c \alpha_c / RT_c$ is substantially constant for all the hydrocarbons, which permits developing a generalized correlation for f/P as a function of T_r and P_r.

The critical constant group $RT_c / P_c \alpha_c$ is defined as $-K_1$ and values of this constant are given in Table 1B in Part VII. It will be noted that the constant does not vary appreciably for the various hydrocarbons.

Reduced Derivatives

From the equations in Table 15 it can be seen that the following derivatives are required for evaluating the generalized thermodynamic equations:

Derivative	Variable	Compressibility Factor	Reduced Volume Residual
1st	P_r	$\left(\frac{\partial Z}{\partial T_r}\right)_{P_r}$	$\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}$
2nd	P_r	$\left(\frac{\partial^2 Z}{\partial T_r^2}\right)_{P_r}$	$\left(\frac{\partial^2 \alpha_r}{\partial T_r^2}\right)_{P_r}$
1st	T_r	$\left(\frac{\partial Z}{\partial P_r}\right)_{T_r}$	$\left(\frac{\partial \alpha_r}{\partial P_r}\right)_{Tr}$
1st	V_r	$\left(\frac{\partial Z}{\partial T_r}\right)_{V_r}$	
2nd	V_r	$\left(\frac{\partial^2 Z}{\partial T_r^2}\right)_{V_r}$	

These reduced derivatives may be found graphically from the P-V-T correlations, such as those given in Figures 19 and 20 of Part IX and the cross plots of these Z and α_r plots. Figures 28 and 29 are cross plots of Figures 19 and 20. With these four plots, the first derivatives of Z and α_r with respect to T_r or P_r may be found graphically.

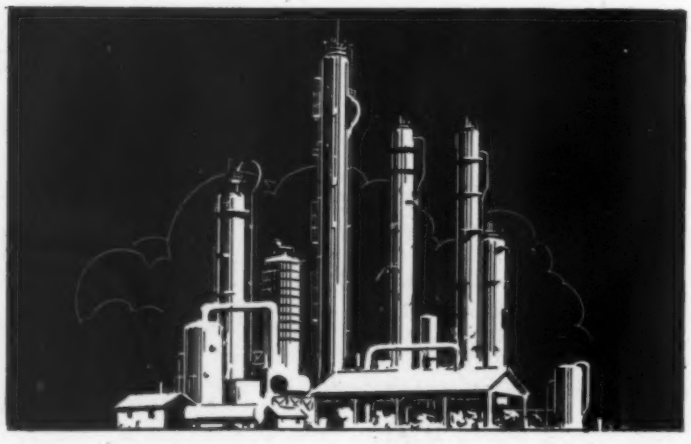
Lines of constant volume could be drawn on Figures 28 and 29 and the constant volume derivative obtained along these lines.

From the first derivatives, the required second derivatives are obtained by the same graphical methods.

In the next installment the graphical methods of differentiating and integrating will be illustrated. Also, tables and graphs of derived thermodynamic functions will be presented.

Acknowledgment. The author expresses appreciation to Hydrocarbon Research, Inc., for stenographic, drafting and technical proof reading assistance in the preparation of these articles.

(End of Part XI, Part XII will appear in the June issue.)



Trends in Supply of High-Sulfur Crusades in the U. S.

H. M. SMITH and O. C. BLADE
U. S. Bureau of Mines, Bartlesville, Okla.

IN 1946 the total production of high-sulfur crude oils reached a new high, and the ratio of high-sulfur crude oils produced to low-sulfur crude oils also approached the all-time peak value obtained in 1925. However, the relative sulfur contents of the estimated reserves of the country show approximately the same pattern in distribution as do the sulfur contents of crude oils currently produced, which would indicate that, until new fields of considerable magnitude are discovered, the ratio of high-sulfur to low-sulfur crude oils should not change materially. Most of the major petroleum districts of the country are now producing a greater volume of high-sulfur crude oil than at any previous time in their history, and in most instances this is true whether in terms of millions of barrels produced or as percentage of the nation's total oil. Further, a great deal of the oil having high-sulfur content is in the range above 1 percent sulfur, and even a good portion of that has more than 2 percent sulfur.

These are some of the conclusions which can be drawn from the consideration of the sulfur content of United States crude oils from the years 1915 to 1946. The data covering this period were accumulated starting with 1915, tabulated, and are presented by means of bar graphs and curves which show the trend in each producing district, both in terms of percent and in terms of millions of barrels of crude oil produced.

This presentation, the essentials of which are reprinted herewith, was before a Division of Refining group session on Sour-Crude Processing during the November meeting of the American Petroleum Institute in Chicago. The authors are connected with the U. S. Bureau of Mines Petroleum Experiment Station, Bartlesville, Okla., and reproduction is by permission of the director, Bureau of Mines.

DURING the past few years there have been many statements to the effect that future supplies of crude oil would include an increasingly large proportion with a relatively high content of sulfur. To the writers' knowledge, such statements have never been accompanied by factual information which would either prove or disprove the validity of such conclusions. What actually in the situation? Is the production of crude oil with a high content of sulfur increasing more rapidly than the production increase of low-sulfur crude oil? Or is low-sulfur crude oil production increasing at all? What is the history of the various major producing areas of the country as regards sulfur in petroleum? Where are the major oil fields today, and what is the sulfur content of the petroleum produced from these fields? What are the prospects for new large fields; i.e., will they produce high- or low-sulfur crude oils? These are some of the questions that should be answered to obtain a proper background from which may be developed some conclusions regarding the future trends in the production of high-sulfur crude oils.

In this paper the writers have attempted to present data that will provide answers to some of the foregoing questions raised. As necessary background, the crude oils produced in the United States over the period 1915 to 1946 have been studied as regards sulfur content and annual production, using 5-year intervals as the time basis. The plan used was to divide the country into nine major producing areas, as follows: California; Rocky Mountain (Colorado, Montana, Wyoming); West Texas-New Mexico; Gulf Coast (Louisiana and Texas); Southeastern (Mississippi); Mid Continent (Arkansas, Kansas, North Louisiana, Oklahoma, rest of Texas); Illinois-Southwest Indiana-Western Kentucky; Michigan - Lima; Appalachian (New York, Pennsylvania, West Virginia, Eastern Kentucky, Eastern Ohio, Tennessee). The next step was to ascertain the production for each of these areas by fields. The sulfur content of the crude oil produced from the fields listed was obtained and the production in each district was divided into groups according to the sulfur content of the

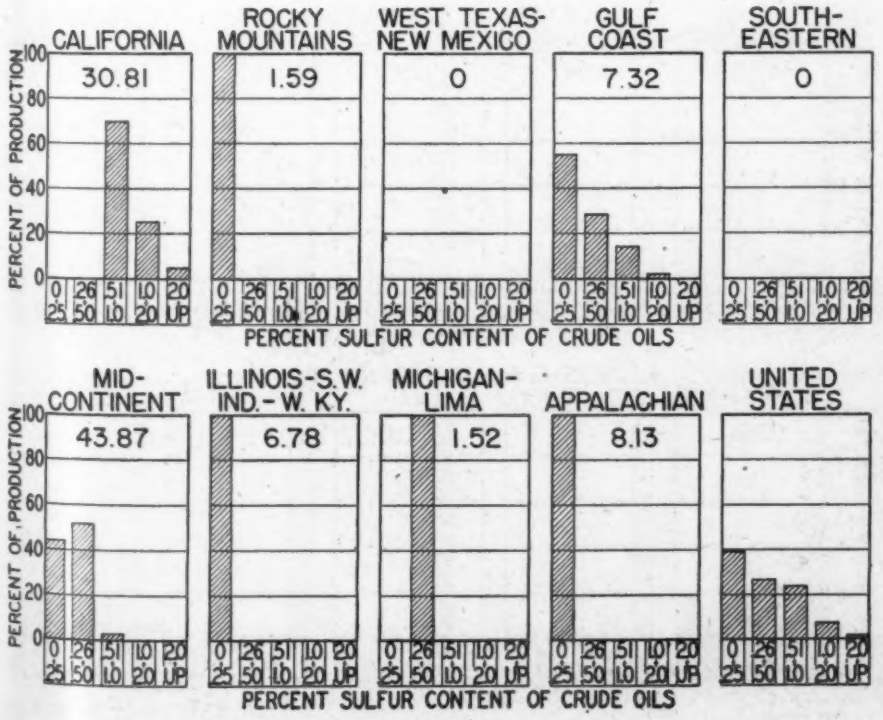


Figure 1. Sulfur Content of U. S. Crude Oils—1915.

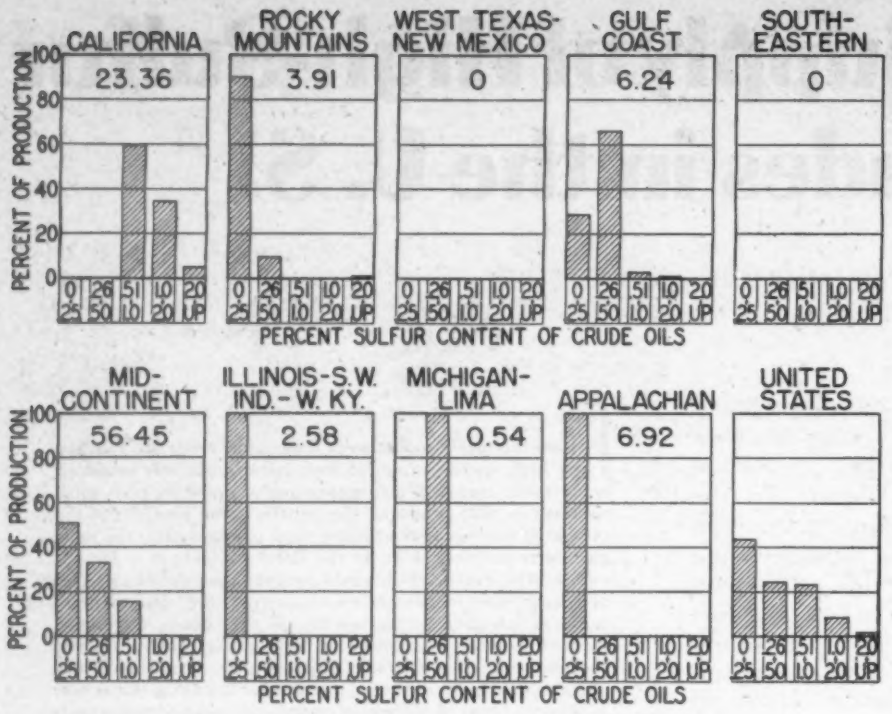


Figure 2. Sulfur content of U. S. crude Oils—1920.

crude oils as follows: 0.0-0.25 percent; 0.26-0.50 percent; 0.51-1.0 percent; 1.0-2.0 percent; above 2.0 percent. The figures were totaled, and the percentage distribution for each group determined on the basis of the total production for which sulfur contents were available. This percentage figure was assumed to apply to the entire United States production for the year concerned, as in most instances the data represents 80 to 90 percent of the nation's total production.

On the basis of these data, seven charts were prepared which portray the percentage distribution of crude oil according to the sulfur-content groupings for the years mentioned. Annual production in barrels for each of the several sulfur groupings also was calculated for the U. S. and for the four most important oil-producing regions that have high-sulfur crude oil.

The Geological Survey Mineral Resources bulletins, and the Bureau of Mines Minerals yearbooks were used as a source of the basic production figures. These figures were supplemented by specific field data obtained from publications by the American Institute of Mechanical and Metallurgical Engineers, World Oil, formerly *Oil Weekly*, and "Oil and Gas Journal." The book, "Petroleum in the United States and Possessions," by Ralph Arnold and William J. Kemnitzer, was also found very useful. The values for sulfur contents of the various crude oils were obtained almost entirely from Bureau of Mines publications. A few of the earlier data were obtained from the "Handbook of the Petroleum Industry," by David T. Day, or from the "American Petroleum Industry," by R. F. Bacon and W. A. Hamor.

Figure 1 is the first of seven charts showing the distribution of the sulfur content of U. S. crude oils, by districts, for the years 1915-46, in 5-year intervals. The ordinate of each group is the percentage of production—*the percentage of the total crude oil produced within the district.* On the abscissa are the five groups into which the sulfur content has been divided. The figure at the top of each bar graph represents the total percentage of the U. S. crude oil production contributed by that district.

Figure 1, 1915 data: For the entire country, we find that about 65 percent of the total crude oil produced had a sulfur content of 0.5 percent or less, most of the remainder containing less than 2 percent sulfur.

Figure 2, 1920 data, reflecting changes since 1915: The over-all picture shows very little change.

Figure 3, 1925 data: U. S. production as a whole showed a slight decrease, having less than 0.25 percent sulfur, but there were very definite increases in the groups having 1 to 2 percent and above 2 percent sulfur, caused largely by changes in California and Mid-Continent production.

Figure 4, 1930 data: The general picture showed a decrease in the percentage of crude oils having extremely low-sulfur content, with corresponding increases in all other classes except those having 2 percent sulfur or more.

Figure 5, 1935 data: The chart indicates various district changes, showing a considerable increase in the group having 0.26 to 0.50 percent sulfur, and an almost corresponding decrease in the percentage of crude oils having less than 0.25 percent sulfur, and with small

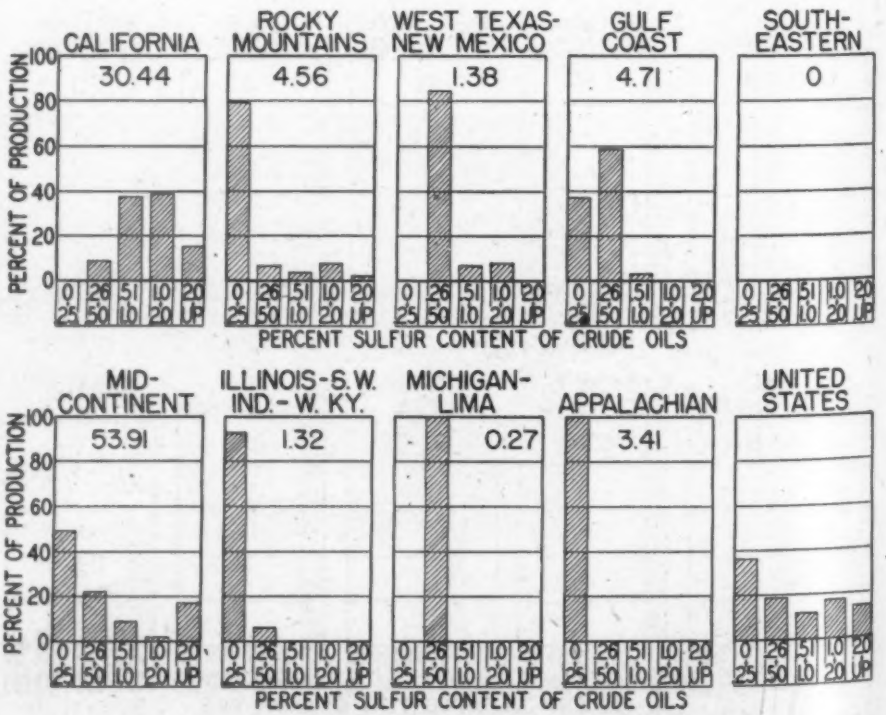


Figure 3. Sulfur content of U. S. Crude Oils—1925.

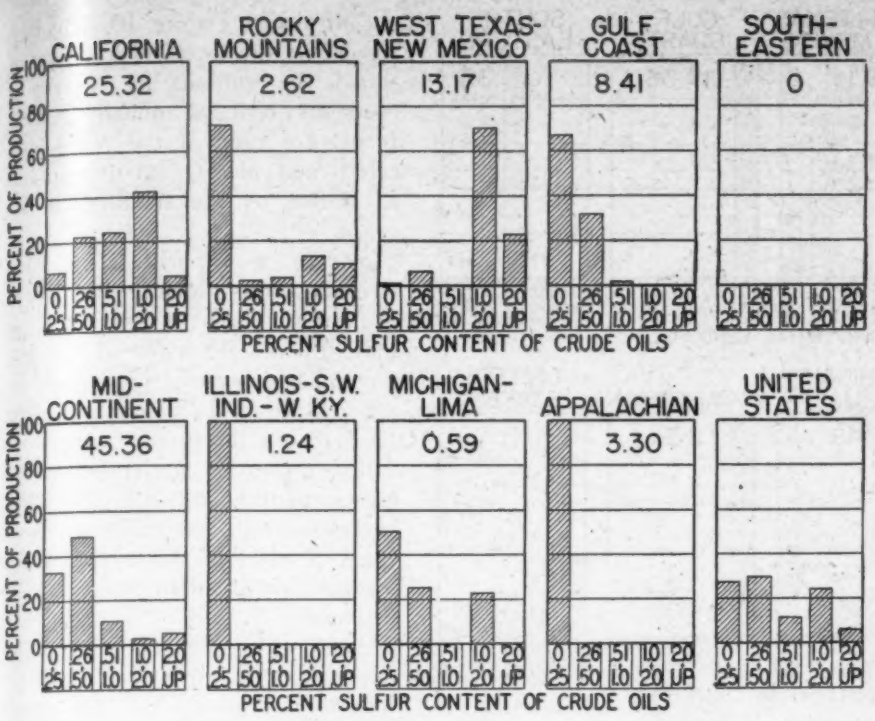


Figure 4. Sulfur content of U. C. crude oils—1930.

decreases in the percentage of crude oils having more than 0.5 percent sulfur.

Figure 6, 1940 data, reflecting changes since 1935: The over-all tabulation reflects Illinois contribution, and for the first time in more than a decade, the production of crude oil having less than 0.25 percent sulfur was greater than that of any other group, being about 38 percent of the nation's total. The percentage of crude oil having more than 0.5 percent sulfur did not change materially. It is probably significant that in 1940, the last year before our participation in the war, the volume of crude oil having less than 0.5 percent sulfur was 67 percent of the nation's total. In other words, this is the background against which many people consider the character of today's production.

Figure 7, 1946: Portrayed are production data on sulfur contents of crude oil produced in 1946, the six-year period covering the war interval, and changes that forced production may have made upon the over-all petroleum picture. For many of the areas, the total production increased, but in some instances it did not.

The over-all view shows a decrease in the proration of crude oil having less than 0.5 percent sulfur. In 1940 it was 67 percent; in 1946 it was 58 percent. This was caused to a considerable extent by the increased production in the California, Rocky Mountain, and West Texas areas, where high-sulfur crude oils predominate, and by decreases in production in the Mid-Continent area and in Illinois.

In considering future production of high-sulfur crude oils, a comparison between the 1946 production according to various sulfur groups and the estimated reserves, divided according to the same sulfur groups, should be significant. Figure 8 is based on the estimated reserves as of January 1, 1947. The most significant thing about the whole chart is that it almost exactly duplicates the production chart of 1946. This would certainly seem to indicate that crude oil is being produced in almost all of the fields at a constant ratio to the reserves available in those fields. The significance of this is that, as long as crude-oil demand requires full production from all fields, no change can be expected in the quantity of high-sulfur crude oil that will be produced. The only factors that could make a change would be: 1) a decrease in demand that would decrease the importance of the high-sulfur oil; or, 2) discovery of new fields. These fields might yield low-sulfur oil which, of course, would increase its proportion; but, on the contrary, the new fields may have high-sulfur oil, and the ratio of high- to low-sulfur crude oils become even greater than it is at present.

Percentage Distribution During 1915-46

In Figure 9 the over-all data for the U. S. have been summarized. The various groupings according to sulfur content for each year have been placed one above another in terms of percentage of the total production for that year, so that the complete bar for each year represents 100 percent production. It is divided into five groupings of sulfur content, indicated by different shadings.

It is interesting to note that on a percentage basis

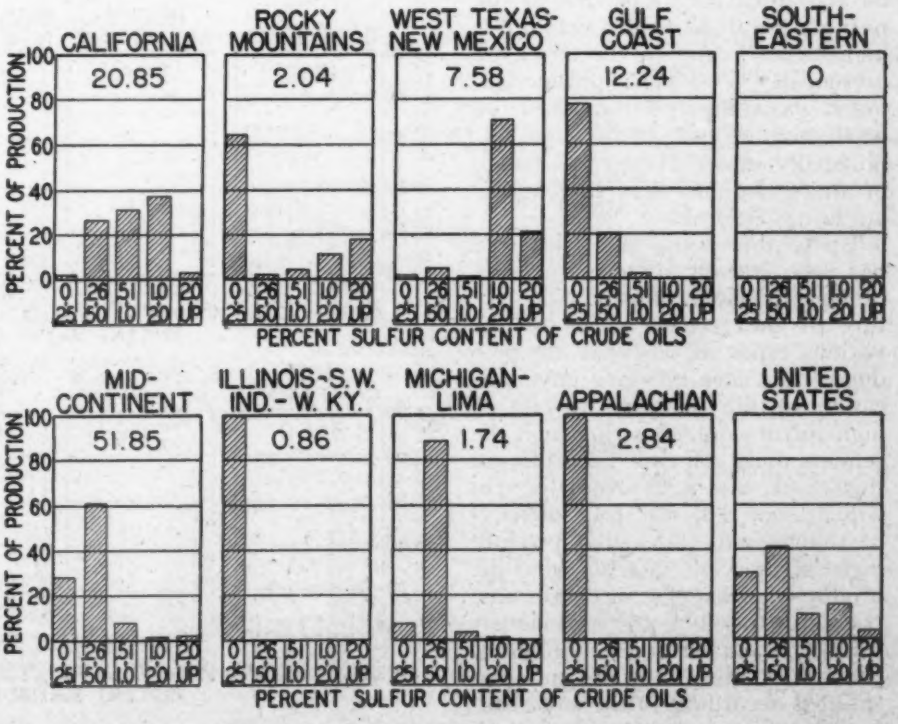


Figure 5. Sulfur content of U. S. crude oils—1935.

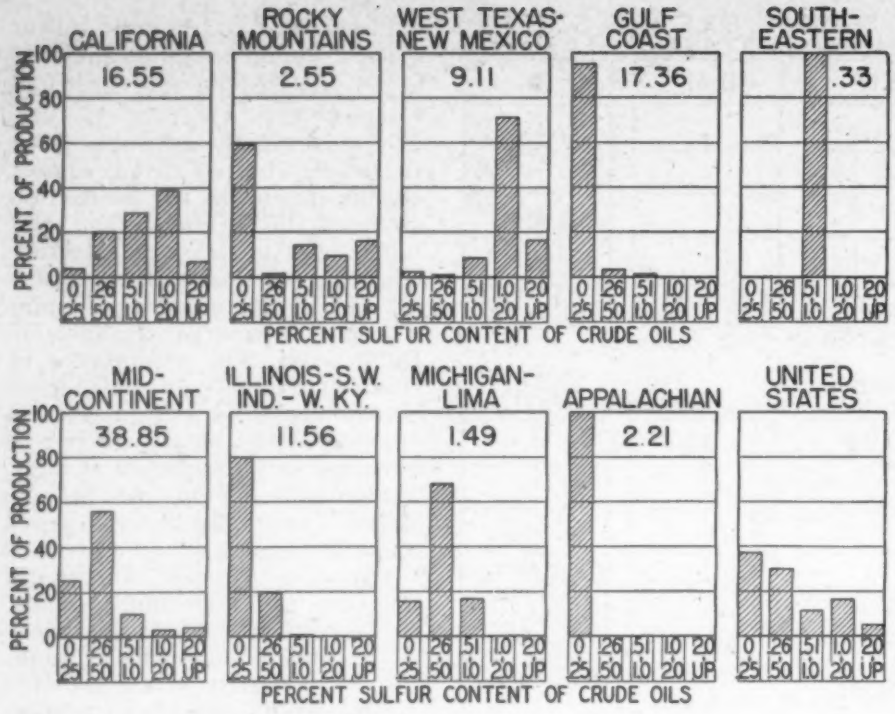


Figure 6. Sulfur content of U. S. crude oils—1940.

the U. S. is still producing more low-sulfur crude oils than it was in 1925 and 1930. The fallacy, of course, is that we are dealing here only with percentages and not considering the actual crude oil in terms of barrels. It is interesting to note that 1915-20 is a period of large percentage production of low-sulfur-content oils, followed in 1925-30 by increased percentage of high-sulfur oils; then in 1935-40 another period of high percentage production of low-sulfur oils and, finally, in 1946 the percentage of high-sulfur production was again increasing. How much further back this cycle might extend, the writers have not attempted to ascertain. They did, however, find the statement that in 1896 Lima crude oil accounted for 41 percent of the nation's total. Now this was not a high-sulfur crude oil in terms of present-day West Texas production, but it was compared to most of the production up to that time, and undoubtedly caused refiners as much, or more, trouble than high-sulfur crude oils do today.

Up to this point, the discussion has been entirely in terms of percentage. This presents a true picture of the relative ratios of the various types of oils that are produced, but does not give any indication of the quantity of oils of high-sulfur content with which the refiners must contend. To bring out this point, the next several figures will present data for four districts of the United States that produce high-sulfur crude oils, showing the production changes in those districts, for the same years previously considered, in terms of millions of barrels of oil produced, and distributed according to the same sulfur groupings.

California: Figure 10, which is typical of the next several figures, shows the millions of barrels of crude oil produced annually in California for each of the years indicated, and having sulfur contents as shown by the shadings in the graph.

Rocky Mountains: The most striking thing about the Rocky Mountain graph (Figure 11) is that, up to 1940, most of the production had been of crude oil having less than 0.25 percent sulfur. At that time the production of high sulfur- crude oils accelerated to such an extent that, although 20 million barrels of very low-sulfur crude oil were produced, about 15 million barrels of high-sulfur crude oil were produced. By 1946 this trend had become still more pronounced. An interesting feature of the Rocky Mountain production is the almost complete absence of crude oils in the range of 0.26 to 0.50 percent sulfur.

West Texas-New Mexico: Figure 12 presents data for the West Texas-New Mexico area. During the period 1925 to 1930 such fields as Crane-Upton, Hendrick, Howard-Glasscock, and Yates were developed, with the result that in 1930 only 8 million barrels of crude oil having a sulfur content of less than 0.5 percent were produced, but there were 110 million barrels having a sulfur content of more than 0.5 percent. The advent of the East Texas field in the 1930-35 period caused a temporary decrease in the total production from the West Texas area.

In the interval since 1940 tremendous increases in production have occurred. In 1946, 178 million bar-

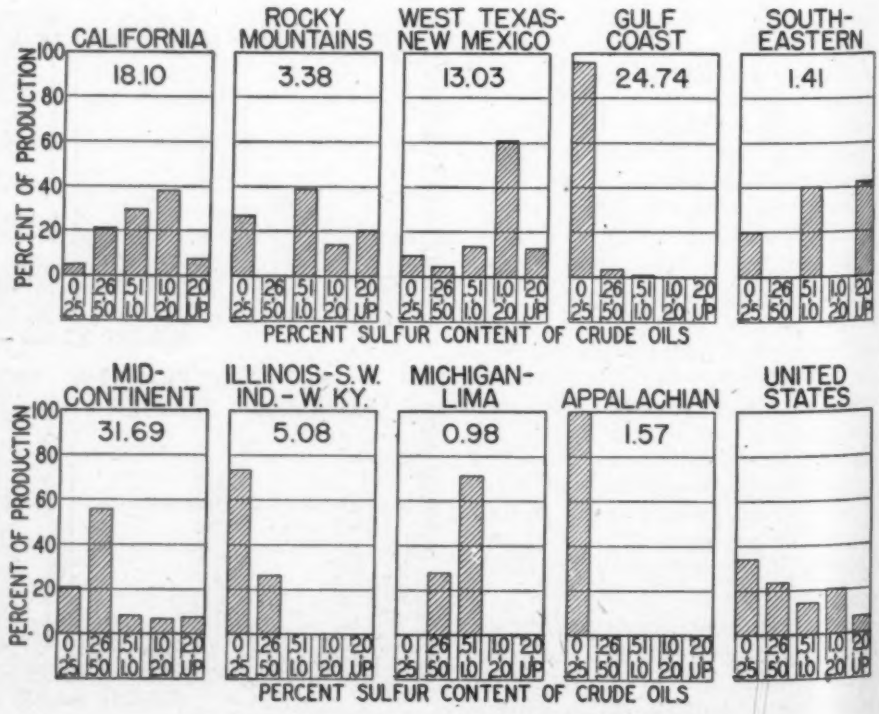


Figure 7. Sulfur content of U. S. crude oils—1946.

rels of crude oil having a sulfur content of 0.5 percent or more were produced, and by far the biggest proportion of this contained 1 to 2 percent sulfur. There is one encouraging feature i.e., the increase of crude oil from the Ellenburger formation, which in 1946 accounted for about 30 million barrels per year of crude oil having less than 0.5 percent sulfur, most of it less than 0.25 percent.

Mid-Continent: Figure 13 presents typical data for the Mid-Continent district. If 0.5 percent sulfur is taken as the dividing line between high- and low-sulfur crude oils, there is very little difference between 1925 and 1930. By 1935 East Texas had become a contributing factor, and about 460 million barrels of crude oil having less than 0.5 percent sulfur were produced in that year, compared with about 55 million barrels having more than 0.5 percent sulfur. Since 1935 the quantity of crude oil having less than 0.5 percent sulfur has decreased to a figure, in 1946, of about 425 million barrels; but the production of fields such as Hawkins and Talco in Texas has increased the output of high-sulfur crude oils, and in 1946 there were about 154 million barrels of such crude oil from the Mid-Continent area, which is higher than for any previous time.

United States: In Figure 14 the data just reviewed for several of the districts, combined with the data from other districts not individually presented, have been combined to give the over-all production for the United States during 1915 to 1946. The millions of barrels of crude oil produced having less than 0.5 percent sulfur and the millions of barrels having more than 0.5 percent sulfur for each of the several years are also given in the following tabulation:

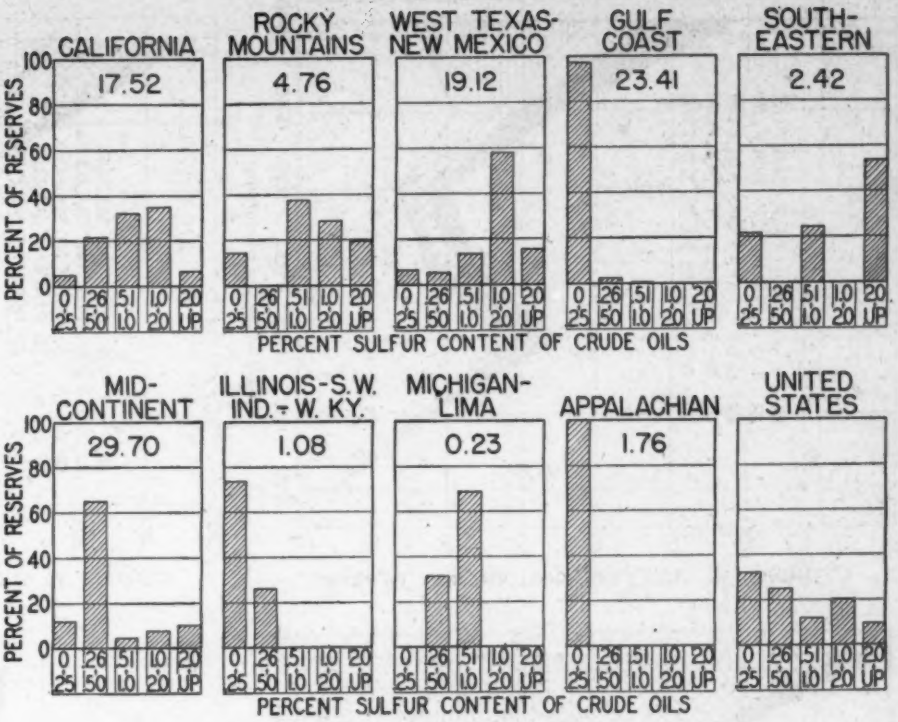


Figure 8. Sulfur content of U. S. crude oil reserves—1946.

United States Crude Oil Production

YEAR	High-Sulfur (Over 0.5 Percent Sulfur)		Low-Sulfur (0 to 0.5 Percent Sulfur)		Ratio of High-Sulfur to Low-Sulfur
	(Millions of Barrels)	(Percent)	(Millions of Barrels)	(Percent)	
1915	95	34	186	66	0.51
1920	144	33	299	67	0.48
1925	339	44	425	56	0.80
1930	382	43	516	57	0.74
1935	295	30	702	70	0.42
1940	444	33	909	67	0.49
1946	735	42	1,014	58	0.72

The table shows the increase in the high-sulfur production during 1925 and 1930, shows that in 1935 the ratio of high- to low-sulfur oils became even smaller than in 1915 and 1920; that it was approximately the same in 1940 as in 1920; but in 1946 the ratio has jumped to another high. Remembering the data presented on reserves, which showed that the reserves had the same approximate ratio between high- and low-sulfur crude oils as does 1946 production, it would appear that this ratio would remain approximately at the 1946 value as long as current demands for crude oil remain the same, and so long as no large fields are discovered. A new "East Texas field" could, of course, change the ratio, just as it did between 1930 and 1935.

This brings out an important point that today we tend to base our evaluation of the quality of current crude oil production in terms of 1935 and 1940 values; further, that production in 1925 and 1930, although it had almost the same percentage of high-sulfur crude oils as today, was confined largely to the California area, except for the Smackover (Arkansas) production. For this reason, it did not affect Mid-Continent and Eastern refiners, but today's production of high-sulfur crude oil comes not only from California, but from the West Texas, Mid-Continent, Southeastern, and Rocky Mountain areas.

Distribution of Crude Production in the U. S.

In order better to visualize the places where crude oil is being produced today and the quality of that crude oil as relates to its content of sulfur, a map (Figure 15) shows the location of all fields having a daily production of 2500 barrels or more. Each location is numbered; and in Table 1 the names of the fields, the sulfur content of the crude oil, and the daily production are given. It is also possible, by looking at the map, to see at once where the high-sulfur oils are produced.

The crude oils indicated on this map represent 73 percent of our 1946 production and more than 83 percent of the estimated reserves.

Conclusions

As a result of the data assembled, it is possible to answer certain questions:

1) *Is the production of crude oil having a high content of sulfur increasing or decreasing more rapidly than the production of low-sulfur crude oil? Is low-sulfur crude oil production increasing at all?*

In terms of both percentage of crude oil and barrels of crude oil produced, there has been an increase in the high-sulfur crude oil from 1940 to 1946. On

(Text continued on page 108. Note intervening map, tables and charts).

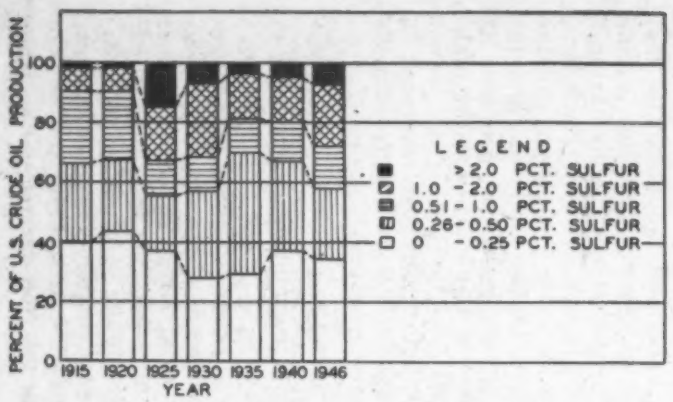


Figure 9. Percentage distribution of U. S. crude oil production according to sulfur content—shown in 5-year intervals, 1915-1946.

Other figures on this page show crude oil production for five-year intervals, 1915-1946, grouped according to sulfur content for the various areas as designated under each figure.

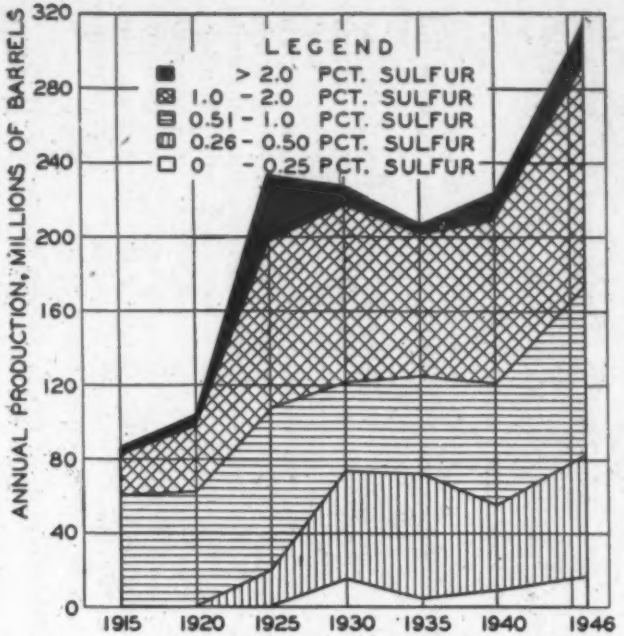


Figure 10. California.

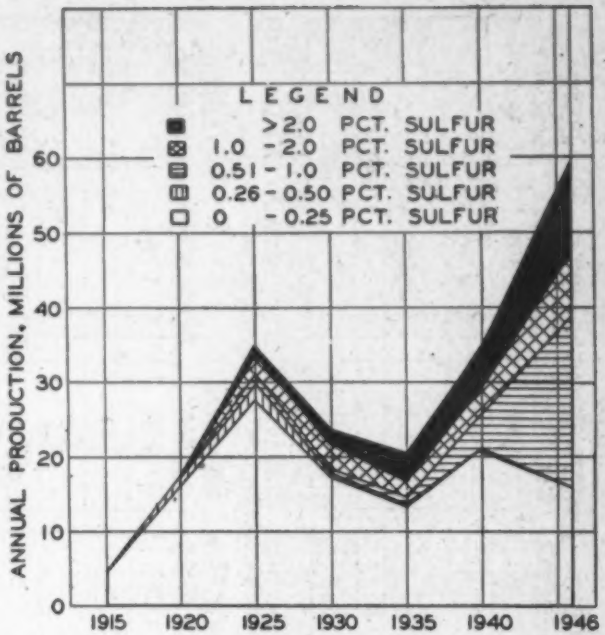


Figure 11. Rocky Mountains.

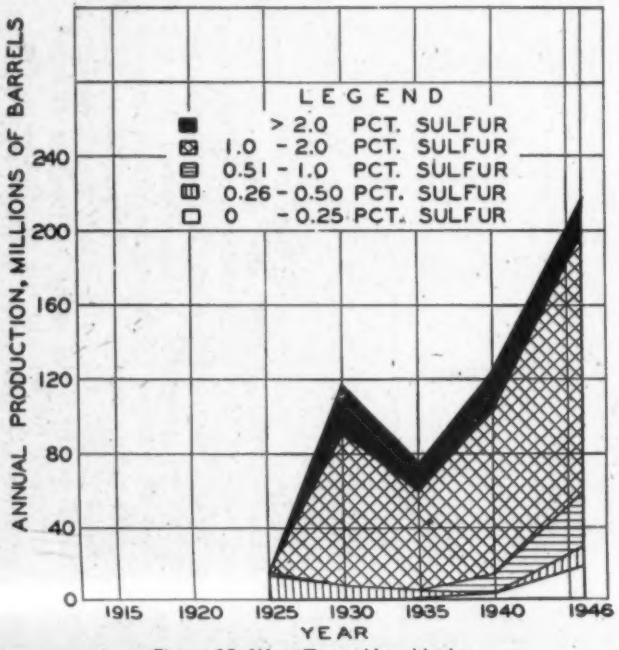


Figure 12. West Texas-New Mexico.

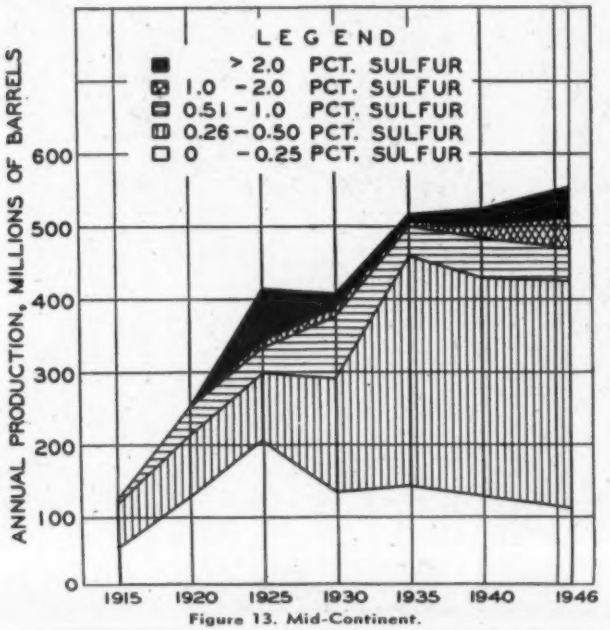


Figure 13. Mid-Continent.

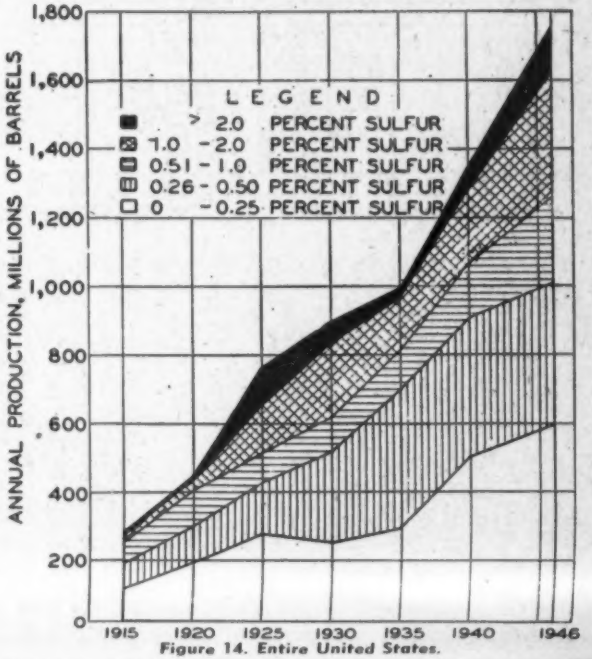


Figure 14. Entire United States.

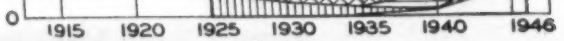


Figure 12. West Texas-New Mexico.

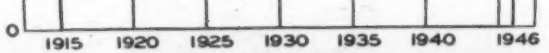


Figure 13. Mid-Continent.

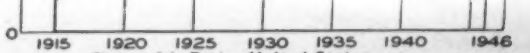


Figure 14. Entire United States.

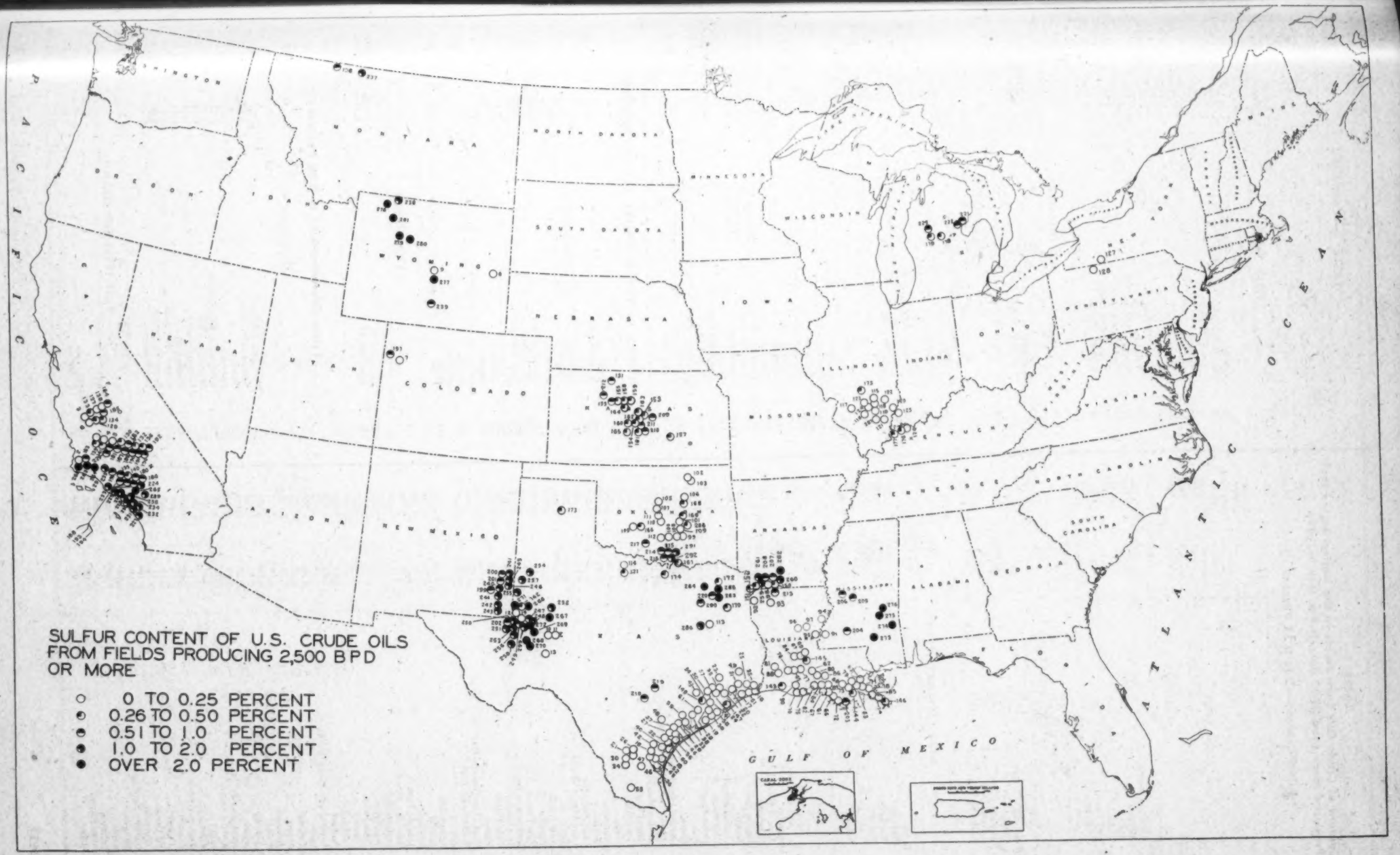


FIGURE 15

Sulfur content of U. S. crude oils from fields producing 2500 barrels per day or more.

TABLE 1

Sulfur Content of Crude Oils from Fields in the United States that Produced More than 2500 Barrels Per Day in 1946

Sulfur Content—0 to 0.25 Percent

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
	CALIFORNIA		
1	Belridge, North	<0.10	5,111
2	Elwood	0.18	7,213
3	Heim	0.21	4,343
4	Paloma	0.10	7,371
5	Rio Bravo	0.22	12,986
6	Riverdale	0.22	4,223
	ROCKY MOUNTAINS		
	Colorado		
7	Wilson Creek	0.11	6,950
	Wyoming		
8	Lance Creek	<0.10	11,975
9	Salt Creek	0.24	12,600
	WEST TEXAS-NEW MEXICO		
	Texas		
10	Barnhart	<0.10	3,600
11	Big Lake	0.18	3,400
12	Embar	0.18	4,000
13	Todd, Deep	0.15	8,500
14	TXL	0.19	26,100
	GULF COAST		
	Louisiana		
62	Anse la Butte	0.17	6,700
63	Barataria	0.14	3,950
64	Bayou Sale	<0.10	9,950
65	Bosco	<0.10	2,952
66	Caillou Island	0.18	6,650
67	Charenton	<0.10	4,000
68	Delta Farms	0.22	13,800
69	Eola	<0.10	4,570
70	Erath	<0.10	18,000
71	Garden Island Bay	0.15	3,750
72	Gibson and Gibson Northeast	<0.10	6,502
73	Golden Meadow	<0.10	7,531
74	Grand Bay	0.14	8,550
75	Gueydan	0.17	4,503
76	Iowa	<0.10	7,303
77	Jennings	0.15	5,202
78	Lafitte	0.14	12,600
79	Lake Salvador	0.13	4,650
80	Lake Verret West	<0.10	3,200
81	Neale	0.14	3,400
82	New Iberia	0.21	4,375
83	Paradis	0.12	10,000
84	Pine Prairie	<0.10	5,000
85	Quarantine Bay	0.12	8,775
86	St. Gabriel	0.17	4,818
87	Ville Platte	0.11	7,308
88	Vinton	0.19	10,000
89	West Cote Blanche Bay	0.15	2,900
90	White Lake, East	<0.10	3,852
	Texas		
15	Agua Dulce	<0.10	10,000
16	Amelia	0.20	3,750
17	Anahuac	0.13	25,200
18	Aransas Pass	<0.10	2,600
19	Bay City, North	0.11	3,900
20	Barbers Hill	0.15	5,150
21	Benavides	<0.10	2,775
22	Clear Lake	0.17	3,400
23	Conroe	0.12	53,000
24	Fairbanks	0.11	5,600
25	Fannett	0.21	7,600
26	Government Wells, North	0.16	3,975
27	Greta	0.22	8,700
28	Hastings	0.24	51,100
29	Heyeeg	0.13	5,050
30	Hoffman	0.14	2,775
31	Hull	0.20	3,000
32	La Rosa	<0.10	3,250
33	Lolita	0.15	5,125
34	Loma Novia	0.10	2,900
35	Lovell's Lake	<0.10	3,750
36	Luby	<0.10	2,500
37	McFaddin	0.11	4,900
38	Magnet-Withers	0.15	6,800
39	Manvel	0.19	6,400
40	Midway	0.12	3,000
41	Old Ocean	0.11	14,750
42	Plymouth	<0.10	8,825
43	Raccoon Bend	0.10	5,600
44	Refugio	0.14	3,625
45	Saxet	0.12	7,000
46	Seeligson	<0.10	33,000
47	Seven Sisters	0.13	6,050
49	Silsbee	<0.10	2,500

TABLE 1—Continued

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
48	Slick	0.17	4,100
50	South Houston	0.20	3,800
51	Stowell-Winnie	0.17	10,250
52	Stratton	<0.10	6,100
53	Sun	<0.10	2,800
54	Thompson	0.20	25,000
55	Tomball	<0.10	8,100
56	Tom O'Connor	0.21	40,000
57	Webster	0.16	48,500
58	West Columbia	0.19	3,850
59	West Ranch	0.13	17,500
60	White Point, East	0.10	10,000
61	Withers, North	0.16	6,000
	SOUTHEASTERN		
	Mississippi		
91	Cranfield	0.12	14,679
	MID-CONTINENT		
	Arkansas		
98	Dorcheat	<0.10	3,986
	Louisiana		
92	Caddo	0.20	9,375
93	Cotton Valley	<0.10	5,970
94	Holly Ridge	<0.10	3,410
95	Lake St. John	0.13	14,550
96	Nebo	<0.10	7,375
97	Olla	0.13	6,265
	Oklahoma		
99	Allen	0.24	2,910
100	Antioch	0.14	5,350
101	Bowlegs	0.20	3,150
102	Burbank	0.20	7,700
103	Burbank, South	0.18	4,700
104	Cement	0.21	13,900
105	Crescent	<0.10	4,015
106	Cushing	0.25	7,550
107	Edmond, West	0.15	43,400
108	Fitts	0.16	3,750
109	Little River	0.25	2,910
110	Moore	0.12	6,240
111	Oklahoma City	0.16	27,450
112	Pauls Valley	0.17	5,425
	Texas		
114	KMA	0.20	16,623
113	Long Lake	<0.10	4,250
	ILLINOIS, SOUTHWEST INDIANA, WESTERN KENTUCKY		
	Illinois		
115	Bible Grove	0.17	3,590
116	Boyd	0.14	3,975
117	Centralia	0.15	4,675
118	Clay City	0.15	20,500
287	Hoodville	0.20	3,700
119	Johnsonville	0.18	2,775
120	Mt. Carmel	0.25	2,550
121	New Harmony	0.24	7,990
122	Noble	0.15	4,300
123	Patoka	0.16	4,450
124	Salem	0.21	15,650
	Indiana		
125	Griffin	0.25	4,650
	Kentucky		
126	Poole	0.22	3,050
	APPALACHIAN		
127	Allegany, N. Y.	0.17	9,500
128	Bradford, Pa.	0.11	35,800

Sulfur Content—0.26 to 0.50 Percent

	CALIFORNIA		
129	Coalinga, Northeast	0.31	58,893
130	Coles Levee, North	0.50	16,150
132	Greeley	0.29	10,506
133	Jacalitos	0.34	4,169
134	Kettleman, North Dome	0.50	37,990
136	Mountain View	0.44	4,702
137	Pleasant Valley	0.35	3,443
138	Raisin City	0.41	2,942
139	Round Mountain	0.43	8,946
140	Santa Fe Springs	0.26	16,685
141	Ten Section	0.37	8,938
	WEST TEXAS-NEW MEXICO		
	Texas		
142	Fullerton	0.48	27,815

TABLE 1—Continued

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
	GULF COAST		
	Louisiana		
143	Hackberry, East	0.26	4,000
144	Leeville	0.38	3,914
145	Forte Barre	0.29	2,900
146	West Bay	0.26	3,500
	Texas		
147	High Island	0.26	2,600
149	Sugarland	0.30	4,000
	MID-CONTINENT		
	Arkansas		
150	Atlanta	0.48	4,283
151	McKamie	0.26	2,887
	Kansas		
154	Bloomer	0.30	8,125
155	Burnett	0.45	8,350
156	Chase	0.26	7,050
157	El Dorado	0.27	7,025
158	Gorham	0.47	4,960
159	Hall-Gurney	0.35	9,225
160	Kraft-Prusa	0.27	15,285
161	Peace Creek	0.32	4,025
162	Silica	0.31	13,950
163	Stoltenberg	0.32	7,250
164	Trapp	0.41	30,100
165	Zenith	0.33	3,210
	Louisiana		
152	Rodessa (Louisiana, Texas, Arkansas)	0.30	8,142
	Oklahoma		
166	Apache	0.38	4,525
167	Cumberland	0.46	10,750
168	Glennpool	0.35	6,650
288	St. Louis	0.36	4,025
169	Seminole	0.27	3,650
	Texas		
170	East Texas	0.30	316,000
171	Hull-Silk-Stkes	0.48	9,766
172	New Hope	0.41	3,050
173	Panhandle	0.38	75,800
174	Walnut Bend	0.37	3,911
	ILLINOIS, SOUTHWESTERN INDIANA, WESTERN KENTUCKY		
	Illinois		
175	Louden	0.26	21,500
	Kentucky		
176	Smith Mills	0.39	2,925
177	Uniontown	0.26	5,160
	MICHIGAN-LIMA		
	Michigan		
178	Coldwater	0.30	4,603
179	Fork	0.32	3,226

Sulfur Content—0.51 to 1.0 Percent

	CALIFORNIA		
180	Aliso Canyon	0.67	3,343
181	Belridge, South	0.86	10,273
182	Buena Vista	0.59	44,850
183	Capitan	0.69	3,338
184	Coalinga, East	0.51	17,505
185	Coalinga, West	0.71	6,631
186	Dominques	0.93	14,912
187	Edison	0.68	15,250
189	Elk Hills	0.76	8,300
188	Fruitvale	0.60	7,284
190	Kern Front	0.89	8,716
229	Kern River	0.93	9,652
191	Lost Hills	0.66	3,823
196	Midway-Sunset	0.88	42,564
135	Montebello	0.60	7,733
192	Mount Poso	0.65	15,233
193	Newhall-Potrero	0.52	5,884
194	Rosecrans	0.53	4,904
195	San Miguelito	0.93	5,675
	ROCKY MOUNTAINS		
	Colorado		
197	Rangely	0.73	25,200
	Montana		
198	Cut Bank	0.77	12,300
	Wyoming		
239	Lost Soldier	0.75	8,350

TABLE 1—Continued

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
	WEST TEXAS-NEW MEXICO		
	New Mexico		
199	Grayburg-Jackson	0.95	5,250
200	Maljamar	0.70	6,175
201	Vacuum	0.87	11,000
	Texas		
202	Keystone	0.84	45,575
	GULF COAST		
	Louisiana		
203	Lake Pelto	0.53	4,000
	SOUTHEASTERN		
	Mississippi		
204	Brookhaven	0.86	10,500
205	Pickens	0.72	4,860
206	Tinsley	0.77	20,921
	MID-CONTINENT		
	Arkansas		
207	Magnolia	0.90	12,914
208	Village	0.80	3,146
	Kansas		
153	Bemis-Shutts	0.60	15,250
209	Bornholdt	0.62	3,120
210	Burrton	0.56	3,222
211	Geneseo	0.54	6,575
212	Morel	0.67	3,475
131	Ray	0.58	3,650
	Louisiana		
213	Haynesville	0.53	8,075
	Oklahoma		
214	Healdton	0.77	6,700
215	Hewitt	0.84	4,650
216	Lone Grove	0.79	4,600
217	Velma	0.81	7,350
	Texas		
218	Darst Creek	0.83	7,000
219	Luling-Branyon	0.92	3,725
220	Quitman	0.87	5,080
290	Van	0.90	24,500
	MICHIGAN-LIMA		
	Michigan		
221	Adams	0.66	3,600
222	Deep River	0.60	8,000
223	Reed City	0.54	8,047

Sulfur Content—1.0 to 2.0 Percent

	CALIFORNIA		
289	Brea-Olinda	1.31	11,402
224	Coyote, East	1.44	4,512
225	Coyote, West	1.21	14,708
226	Del Valle	1.14	4,731
227	Huntington Beach	1.26	47,899
228	Inglewood	1.84	11,979
230	Long Beach	1.34	24,180
231	Newport Beach	1.99	6,904
232	Richfield	1.09	6,689
233	Rincon	1.11	4,133
234	Seal Beach	1.23	10,693
235	Ventura Avenue	1.17	44,906
236	Wilmington	1.24	117,667
	ROCKY MOUNTAINS		
	Montana		
237	Kevin-Sunburst	1.47	5,000
	Wyoming		
238	Elk Basin	1.72	11,500
	WEST TEXAS-NEW MEXICO		
	New Mexico		
240	Arrowhead	1.30	4,400
241	Eunice	1.24	13,750
242	Hobbs	1.45	9,750
243	Langlie	1.35	3,400

TABLE 1—Continued

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
244	Loco Hills	1.02	2,600
245	Monument	1.39	17,675
246	Penrose-Skelly	1.04	3,515
	Texas		
247	Cowden, North	1.66	21,000
248	Cowden, South	1.38	2,700
249	Foster	1.07	17,000
250	Goldsmith	1.90	20,700
251	Hendrick	1.49	3,700
252	Iatan-East Howard	1.40	3,750
253	Kermit	1.45	2,650
255	Seminole	1.76	18,600
254	Slaughter	2.00	46,000
256	Ward, North	1.21	9,100
257	Wasson	1.90	69,650
258	Yates	1.59	41,800
	MID-CONTINENT		
	Arkansas		
259	Midway	1.36	7,219
260	Schuler	1.54	8,985
261	Stephens	1.99	4,455
	Oklahoma		
291	Tatums	1.67	4,025
292	Tussy	1.54	2,725
	Texas		
286	Cayuga	1.90	6,500
	Sulfur Content—Over 2.0 Percent		
	CALIFORNIA		
262	Gato Ridge	5.21	3,574
263	Santa Maria	2.63	13,520
264	Santa Maria Valley	4.73	30,798
265	Torrance	3.29	8,299

TABLE 1—Continued

No. on Map	FIELD NAME	Sulfur Content	Average Daily Production, 1946 (Barrels)
	WEST TEXAS-NEW MEXICO		
	Texas		
266	Fuhrman-Mascho	4.17	3,650
267	Howard-Glasscock	2.76	14,000
268	Jordan	2.13	5,350
269	McCamey	2.23	8,200
270	McElroy	2.39	27,000
271	Means	2.36	3,500
272	Penwell	2.59	2,700
	SOUTHEASTERN		
	Mississippi		
273	Baxterville	3.07	8,061
274	Eucutta	3.89	6,805
275	Heidelberg	3.50	13,569
276	Heidelberg, East	3.50	10,026
	ROCKY MOUNTAINS		
	Wyoming		
277	Byron	2.42	5,850
278	Frannie	2.52	3,450
279	Grass Creek	2.72	2,950
280	Hamilton Dome	2.30	2,625
281	Oregon Basin	3.27	9,450
	MID-CONTINENT		
	Arkansas		
282	Smackover	2.36	11,365
	Texas		
283	Hawkins	2.45	39,200
284	Sulphur Bluff	2.95	3,350
285	Talco	2.98	24,000

the same basis, the percentage of low-sulfur crude oil has decreased; but its volume in barrels has increased—not as rapidly, however, as the increase in high-sulfur crude oil.

If the reserves as estimated for January 1, 1947, can be used as a guide, it would appear that the increase in high-sulfur crude oils should not continue further, but that the ratio between high-sulfur and low-sulfur crude oils should become stabilized at about the point it was in 1946—unless new fields of considerable magnitude are discovered.

2) What is the history of the various major oil-producing areas of the country as regards sulfur-containing petroleum?

California production is largely in the high-sulfur class, and its production in barrels has increased slightly since 1940. West Texas production of high-sulfur crude oil has increased greatly since 1940; and the production of low-sulfur oil, although small, is also increasing in this area.

The Gulf Coast does not produce any high-sulfur crude oil. Mississippi, as its production increases, provides more and more high-sulfur crude oil.

The Mid-Continent area, with the new discoveries in Arkansas and eastern Texas, southern Oklahoma, and western Kansas, is contributing more high-sulfur oil than ever in its history.

Illinois is definitely an area of low-sulfur crude oil.

The Rocky Mountain region is producing more high-sulfur crude oil than at any previous time.

3) Where are the major fields today, and what is the sulfur content of the petroleum produced from these fields?

The major oil fields today are located in five or six districts, viz.: California, West Texas-New Mexico, Gulf Coast, Mid Continent; and probably the Rocky Mountain and Mississippi regions should also be considered. In general, the sulfur content of these oils is as follows: California is typified by large production having more than 1 percent sulfur and a considerable quantity having more than 2 percent sulfur. The West Texas-New Mexico area likewise has considerable yield having greater than 2 percent sulfur, and most all of it has over 1 percent sulfur. The Gulf Coast produces virtually no high-sulfur crude oils. Mississippi, for the most part, produces crude oil having sulfur contents ranging from 1 to 2 percent. This is also true of fields such as Talco and Hawkins in the East Texas area, and many of the Arkansas fields also have sulfur contents well over 1 percent. A few of the Oklahoma fields and several Rocky Mountain fields also are in this category.

4) What are the prospects for new fields?

The new low-sulfur crude-oil production from the Ellenburger formation in West Texas is very encouraging. Also some of the newer fields being explored and developed in Oklahoma are in the region that should produce relatively low-sulfur crude oils; and, of course, any development in the Gulf Coast should likewise result in very low-sulfur oil. It seems probable that developments in the Rocky Mountains may conform to the trends already indicated, and presumably the Kansas production will remain intermediate as it has up to the present time, with emphasis on the high-sulfur oils.

* * *

Instrument Maintenance

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THE first requirement for utilizing instruments is that of maintenance personnel. The instrument maintenance crew should be headed by someone with a minimum of two years' experience with measurement and control, preferably in the industry concerned. A degree in chemical, electrical, or mechanical engineering is an asset, and in many cases, essential. Quite often the plant instrument engineer is also the head of the instrument maintenance department and also plant electrician. The maintenance chief should have a fair knowledge of the plant processes, a knowledge of electrical and electronic equipment and circuits, a knowledge of the principles of hydraulics as applied to fluid flow in orifices, valves, pipes, and nozzles, a good grounding in the practical aspects of pyrometry, pressure measurements, and mechanical equipment. By way of personality, he should have a reasonably even temper and sense of humor (he will certainly need both). He should be able to teach what he knows about instruments to inexperienced assistants.

THE ideal instrument of the future will need no maintenance. Its burglar-proof case will defy the most powerful and curious of meddlers. Its highly efficient air filters will remove all dirt, oil, scale, and moisture. Its recording pen will write—not for a year, not for life, but forever, under water if necessary. The droops and surges and harmonics of the electric supply will be smoothed to a graceful sine wave of constant amplitude. Its truly oil-less bearings will run silently, until the perfect, guided missle of the enemy reduces it to a pile of radioactive dust. For the present, however, let us discuss means of keeping what we have operating as the manufacturer intended.

"Lively Interest" Is Essential

The instrument men working under this head need not necessarily have previous experience with the equipment involved, but they should have a lively interest in measurement and control. They may be chosen from other plant occupations which acquaint them with the processes or manufacturing steps which are to be controlled. Care should be taken that these men are not just angling for what they consider a soft job, or possible freedom from shift work. The instrument man should be of a type who does not try to impress people with his knowledge, or to antagonize them in general. Hobbies of a certain nature are a fair indication of natural aptitude in the absence of an experience record. Thus an applicant who is a radio amateur, a model train enthusiast, or a home gadgeteer who puts strange devices on his stoker, is a good bet as an instrument trainee.

By way of training, a plant school may be established, either on company time, after hours, or on a fifty-fifty basis. Instrument companies run excellent training courses to which trainees may be sent if both time and money are available. In the absence of either of these systems, the trainee may be assigned to an experienced man as helper or apprentice, until he becomes proficient enough to go on his own. During this time he should do as much as possible with his own hands, rather than just watch. All calibrations and adjustments should be checked until the trainee has proved his ability.

There are two schools of thought on the organization of a maintenance department from a personnel standpoint. One school advocates having each man a specialist in a particular type of instrument; he need know little or nothing of others. Thus, a department would consist of a pressure gauge expert, a pyrometer recorder expert, a level recorder expert, etc. The other school is that which rotates the training and experience so that each man is qualified to work on any number of types of equipment, even though less proficiently.

The author is inclined to favor the latter—with a strong dash of the former—to get a hybrid species that is able to work on almost anything, but has certain specialties depending upon previous experience, education, hobbies or personal preference. With the accent upon electronically actuated recorders and controllers prevalent today, it is highly desirable to have an electronic technician to help out on maintenance and trouble shooting where other instrument men who are very good on mechanical instruments have difficulty. Electronic training is very difficult to get across in a short time.

Preventive Maintenance Plan

There are also two schools of thought with regard to preventive maintenance and repair. In many cases the instrument man has so much to do that his work may consist only of rushing from one point to another to replace parts as they wear out or fail, to oil instruments when they squeak or plain stop working, and to remove dirt when it has completely fouled operation. Preventive maintenance involves a regular program of calibration checks, lubrication, cleaning, replacement of parts, and checking adjustments. Preventive maintenance may require more manpower, but the improvement in operation, and the elimination of costly shutdowns or spoilage is well worth the effort of having a definite preventive maintenance program. Morale of personnel is also improved. Emergency repairs are still a necessity, of course.

Preventive maintenance calls for a system of records. One system is to have a loose leaf notebook,

each sheet of which covers one instrument, along with its serial number, plant location, and application. A number of headed columns call attention to required preventive maintenance. The dates of such maintenance, as well as of emergency repairs, are recorded, with the serviceman's initial. Sheets may be filed according to plant location, or according to instrument type or manufacture. A card index system may be preferred over a notebook system, but is not so readily portable.

Records are also important from the standpoint of training. Often a check-off system is used. This indicates instruction in particular branches of instrumentation, as well as experience in that particular branch. In larger instrument departments, various grades of instrument maintenance men may be established, dependent upon experience, aptitude, and training. Thus, grades of instrument helper, instrument helper, instrument mechanic, senior instrument man, etc, may be established, with varying degrees of salary and responsibility.

Role of a Library

A small library is a help in training instrument men. A file of manufacturer's instruction pamphlets is a must for this library. Manufacturer's catalogs are very often a better way of acquainting the novice with the principles of a particular instrument than the instruction sheets by virtue of the more entertaining pictures and less ominous sounding text. *Instruments Magazine*, the *Review of Scientific Instruments*, and *Electronics*, as well as periodicals of the manufacturing industry involved, are suggestions for current literature to be circulated or made available for home reading. Chemical, electrical, mechanical or electronic engineering handbooks are compact sources of information for reference, as are many publications of the National Bureau of Standards.

The instrument shop should be a service center for equipment not readily serviceable in the field. Bench space need not usually be provided for every man, since most departments will have about half of the help at large in the plant on service or preventive maintenance work. Space should be provided to separate clean work from dirty work. If moving coil meters must be serviced, a reasonably dust-free room should be provided. Iron dust has an annoying habit of sticking to permanent magnet fields and fouling the moving coil or galvanometer. Neatness of surroundings should be stressed, since it encourages more careful work on delicate mechanisms.

By way of tools, in addition to the usual wrenches, screwdrivers, etc., special manufacturer's tools peculiar to their particular instruments should be provided, since in many cases they save valuable time. A torch for brazing, soldering, and for welding thermocouple junctions is a necessity. Ordinary gas from the mains, plus an oxygen tank and regulator, is sufficient. Pipe and machinist's vises are required, and a portable electric drill. If a machine shop is not available, a drill press, and perhaps a small lathe are useful, particularly for control valve repairs, or for turning such items as rotameter floats.

Testing and standardizing equipment is necessary to maintain the accuracy and reliability of instruments. For thermocouple work, a portable potentiometer covering the full range of temperatures, or from zero to sixty millivolts, is required. If the portable does not have a variable voltage source, or "battery box" for testing moving coil meters, an external one should be provided. For work with pH instruments, a portable pH meter, buffing solutions, and another portable potentiometer reading from 0 to 1.1 or more volts should be provided, or be available in the plant. The one-volt potentiometer is very useful as a standard in checking d.c. ammeters, voltmeters, or standard cells. A combination Wheatstone bridge and decade resistance box is also useful in standardizing, as well as in emergency winding of resistance coils in instruments. If electronic type instruments are used, a volt-ohm-milliammeter is a necessity, and a gas or vacuum tube tester is very desirable. The latter may be eliminated if a large replacement stock of electronic tubes is available for comparison tests.

By way of pressure standards, the dead weight tester is the most reliable in the range of 15-10,000 psi. For a smaller shop, or for portable use as a secondary standard, well-calibrated, and well-kept Bourdon gauges with a hand pressure pump are satisfactory. The latter is especially useful for checking pressure recording and controlling instruments in place. For pressures in the range of 0-15 psig., a single-leg, well-type manometer is more accurate than the dead weight tester, since friction and oil viscosity tend to make the latter less reliable at these pressures. This same manometer may be used for testing vacuum Bourdon gauges, and for the higher ranges of flowmeters and differential pressure meters in general. Plant instrument air and vacuum should be available in the shop for pressure measurements and for instrument checking. In the absence of a regular plant supply, a small compressor should be provided, and a vacuum pump where vacuum measurements are made, or where evacuation of systems is required, such as for gas, vapor, or liquid filled thermal systems in conjunction with temperature instruments.

Indicating pressure gauges should be clearly labeled as to tube materials, and in many cases as to service. In food or the more exact chemical industries, serious contamination could result by interchange of gauges from one service to another. Maintenance personnel should be cautioned with regard to the danger involved in the use of oil for testing gauges used on oxygen tanks or lines, and in using the wrong Bourdon tube for chemicals such as ammonia, corrosive or volatile acids, caustics, and the like. Pressure gauges which have not been decontaminated may be a serious danger to the instrument man because of poisonous or corrosive compounds, particularly when they have become plugged at high pressures, and the compounds are released as the obstruction is removed. Indicating pressure gauges which have become hopelessly plugged or ruptured should be returned to the manufacturer for repairs, since repair or replacement of Bourdon tubes in the instrument shop is seldom economical.

Temperature Standards

For most plant work, temperature standards may be standardized thermoucouples, thermometers with Bureau of Standards calibration, and for the higher temperatures, optical pyrometers. Platinum-rhodium standard couples are best at temperatures from about 600 to 2000° F. For laboratory work, melting point standards obtainable from the Bureau of Standards are convenient in calibration of couples. The ice-point, steam point, melting points of tin, lead, zinc, aluminum and copper are commonly used. Thermocouples must be protected from contamination with calibrations of this sort, and melting metals must be protected from

oxidation with carbon dust and crucibles specially constructed. Bureau of Standards bulletins covering such measurements are available. Precision potentiometers, rather than industrial, should be used for very accurate calibrations. Resistance thermometer calibrations with standardized elements are capable of very high precision and accuracy in the lower and minus temperature ranges, when used with precision potentiometers.

Water column manometers are used for calibration of differential pressure instruments such as flow and liquid level types. Single-leg well-types are much more convenient to use than simple U-tubes. Water manometers are used for differential instruments ranges up to about 50 inches of water. Above this range a mercury manometer is more convenient and portable. Inclined gauges should be used for the range of 2 inches and lower.

A standard orifice calibration apparatus is available from the manufacturers of displacement gas meters. This is convenient and accurate for gas or air flow calibrations in the range of 20 cubic peet per hour to 6000 cubic feet per hour. For smaller and intermediate gas flow calibrations, displacement tanks using water or oil to displace the gas are very good. For liquid flow calibrations, calibrated tanks and stop-watches are used. For all flow calibrations, good pressure regulators should be used to maintain steady flows, and temperature should be maintained as steady as is practical. All corrections such as barometric pressure, temperature, static pressure, water content of a gas, specific gravity, and—in many cases—viscosity, should be made; or, at least, it should be made certain that such corrections are not large as compared to the accuracy required.

Spare Parts Also Essential

An essential part of the instrument shop equipment is a supply of spare parts. Upon ordering a new instrument, the manufacturer will recommend a list of spare parts, most of which consist of items of short life, or those which are easily broken. Experience with a particular instrument is the best means of finding out which parts are most likely to need replacement. Cannibalization, or borrowing parts from an instrument which does not happen to be in use, is often necessary, but it has the disadvantage of making two repair jobs instead of one. Improvised parts and haywire repairs should be avoided. Prompt replacement of spares as they are used is particularly important in these days of long deliveries.

Besides spare parts, there are those which are classed as running maintenance parts, such as charts, ink for recorders, lubricants, pens and pen cleaners, mercury, thermocouple wire and insulators, and chemicals for pH electrodes and for gas analyzing equipment. Where recording is necessary to observe trends, but where the records are not filed, the permanent-type charts, where the record is washed off or erased, may be an economy.

Coordination with other departments by the instrument maintenance department is essential to successful utilization of instrumentation. If the instrument engineering department is a separate organization from the maintenance department, the purpose and specifications of new instruments should be made known to the maintenance man, and all maintenance instructions should be turned over to him. Coordination with the process engineer by the instrument engineer often can simplify the maintenance man's job by eliminating headaches. For example, the storage time in vessels under liquid level control, if properly calculated, can make instrument adjustment much more simple, as can the proper location of valves, the allowance of the proper pressure drop across valves, the correct location of thermocouples, and the elimination of troublesome process lags. The maintenance man should report all major defects and troubles to the instrument engineer to assist him in future specifications, and to enable the instrument engineer to present his point of view.

Operating Personnel Cooperation

Coordination with plant operating personnel eliminates many troubles and arguments. The instrument maintenance man should request that operators make all plant process adjustments or have the operator's sanction of any plant adjustments he may make himself. Further, an explanation of what he proposes doing will usually improve cooperation. Such a policy not only makes for better relations, but relieves the service-man from excessive responsibility, and contributes to safety. Where disagreements on policy arise, they should be referred to those in higher authority.

The instrument man should, on occasion, take the manufacturer's representative on inspection trips to exchange views on servicing procedure. These trips and conferences are helpful to both parties.

Jurisdictional troubles with other workers frequently arise. A clear understanding should be had with the management as to whether or not the instrument man should do certain piping, make electrical connections, do drilling or machine work, and the like. Concessions must be made where general, harmonious relations may be upset. In any case, the instrument man should be able to supervise installation work, or repair work done by other departments, to insure proper operation, whether he does the actual labor or not.

Personnel Requirements

It is difficult to make generalizations as to the number of instrument men required in relation to the cost of instruments, but I will hazard a few guesses. Up to about $15,000 worth of automatic control equipment requires one man, unless around-the-clock maintenance is desired, in which case three men are the minimum. Possibly the one man won't object to being called out of bed occasionally for an emergency repair. Fifteen to $40,000 requires two men, or three men per three shifts; $40,000-$100,000 requires three men, four for three shifts. If plant conditions are dirty, or the atmosphere or processes conditions are extremely corrosive, these figures should be increased. Possibly for cost of instrumentation above $100,000 one man extra for each $50,000 is a fair figure.

Shop area should require about 100 square feet of floor space for each worker, including storage space, with some extra for locker and washroom facilities if these are not available elsewhere.

* * *

Researcher prepares to measure in a Geiger counter the isotope content of a sample precipitated from coal-made gasoline.

New Weapon of Science—

Radioactive Isotopes

A RESEARCH project to unlock the still unknown secrets which make possible conversion of coal and natural gas into gasoline has been launched by Gulf Oil Corporation.

Radioactive isotopes—one of the newest weapons of science—and many of the latest research techniques, are being applied in the study, being conducted by the Corporation's fellowship at Mellon Institute in Pittsburgh.

The reason for the project is that the basic nature of the chemical reaction, by which gasoline is produced from coal, remains a mystery.

Sufficient technical knowledge exists to proceed with commercial production. But whether present methods approach, or fall far short of, the ultimate possibilities cannot be judged until what happens in the reaction is better understood.

The coal-to-gasoline development is based on the Fischer-Tropsch process.

It involves the production, from coal or natural gas, of hydrogen and carbon monoxide, which are then converted to gasoline by passing them over a metallic catalyst.

It has been assumed—but never proved—that such gasoline is produced by the reaction of hydrogen with metal carbides (which have been formed during the process from carbon monoxide and the metal catalyst).

If, however, the gasoline is created by some reaction not involving metal carbide formation, as appears possible, the whole viewpoint on the process, and on its commercial application, might well be changed.

To trace this process scientifically, researchers on the project are using radioactive tagged atoms, or isotopes of carbon, called carbon 14. The carbon 14 atom has the same properties as the carbon atoms normally used—except that it is radioactive.

By sampling for the presence of the radioactive atoms in various stages of the process by a Geiger counter, the researchers hope to trace the course of carbon atoms, and blueprint the entire reaction.

A fog of condensed air as laboratory worker fills a dewar flask with liquid nitrogen preparatory to precipitating a sample of coal-made gasoline. Dr. J. T. Kummer, Gulf Oil researcher, in background.

Dr. Kummer precipitates sample from coal-made gasoline prior to determining its radioactive isotope content in a Geiger counter. Researchers seek the true nature of the synthesis involved.

Applications of the Fluid Catalyst Technique to Catalytic Cracking And Hydrocarbon Synthesis

R. W. KREBS, Esso Laboratories, Baton Rouge, La.

A HIGHLY informative and detailed discussion that will bring the reader up to date on the fluid catalyst technique and its application to hydrocarbon synthesis is presented here. Dr. Krebs appeared before the Western Petroleum Refiners Association in Galveston last month and the material of the paper reflects the interest and research being given to the synthesis of hydrocarbons from natural gas and coal at the present time.

Outstanding in his discussion of the potentialities of synthesis for the production of liquid fuels was Dr. Krebs' presentation of data concerning the production of chemicals from 10 natural gas synthesis plants. Besides liquid fuels, the chemical production of these 10 plants would amount to an average of 68 percent of the product now produced by the present U. S. organic chemical industry. Dr. Krebs points out that it is evident that if the petroleum industry starts producing oil synthetically, it will immediately become also the major producer of basic organic chemicals.

THE new technique in chemical engineering, fluidization, is of increasing importance in process plant design applications. This technique is not only a method for handling and transferring finely divided solids in process vessels, but an excellent means of contacting gases with solids for use in such well-established unit operations as heat transfer, gas-solids mixing or mass transfer. It seems logical, therefore, to consider the fluidization technique as deserving careful study. Quite rapidly, new and different applications for modifications of this technique are being discovered, not only in the catalytic field but in purely physical processes as well.

Probably the two most important properties of a fluidized solids mass are the rapid transfer of heat which can be obtained and the intimate contact of gases with solids which is possible. To illustrate the applications of fluidization, two widely different processes in which most of the properties of fluidized solids are utilized may be considered. The first, fluid catalytic cracking, now well known, is the process in which the fluidized solids technique was proved commercially feasible. The second, hydrocarbon synthesis, is a process of the near future, made commercially attractive by the development of the fluidization technique.

This new "unit operation" is based on two properties or characteristics of finely divided solids described as follows: 1) Solids of a proper particle size range when intimately mixed with a gas will form a homogeneous solids-gas mixture with properties of a fluid. This fluid resembles a liquid except that its density can be varied either by changing the ratio of solids to gases or by adjusting the flow conditions. 2) A finely divided solid when suspended in a gas stream flowing upward at relatively low velocities will form, contrary to Stokes' law, a continuous dense phase closely resembling a boiling liquid with a relatively well defined level or meniscus.

The fluid characteristics of a powdered catalyst can be illustrated by simple apparatus.

"A box containing a sealed chamber in the bottom covered with a porous metallic plate is used for demonstration purposes. Air is supplied to the bottom through a hose and a valve controls the rate of air flow up through the porous plate.

"Catalyst is poured into the box. In this state, the catalyst appears and behaves just like any ordinary fine sand. It can be worked into piles, or swirled around, and it holds its position. Objects can be placed anywhere in it, and they remain on the surface. The catalyst bed is dense and will support them.

"This state is sharply altered when air is turned into the sealed lower chamber.

"As the air rate is gradually increased some of the objects slowly submerge into the catalyst, while others stay on the surface. This is caused by the rising air, which supports the catalyst, thus making the bed less dense. All objects of greater density than that of the bed sink. All those of lesser density float. With further increase of air flow, bubbles appear and the bed seems to boil. The light objects bob around and the catalyst appears and behaves just like a true liquid. But it returns to its original state the instant the air is stopped.

"With air flowing we have a fluid; with no air, a solid. As further illustration, cork buried in the static catalyst bed will rise to the surface and float as aeration is established.

Catalyst Flow and Cyclone Function

"As air or other vapor is introduced into a fluid catalyst bed the catalyst gradually begins to boil until it reaches a state of violent agitation. The entrainment of solid particles from such fluidized beds is relatively small, even though the agitation within the bed is tremendous in current fluid catalytic cracking operations. These relatively small amounts of entrained catalyst pass to cyclone separators at the top of the vessel containing the catalyst bed. Here, tangential motion forces the catalyst to the cyclone wall, so that it is separated from the gas, which escapes at the top. Visual inspection of transparent models and catalyst bed temperature measurements in commercial units have demonstrated that a high degree of agitation exists in the catalyst bed. In the actual operation the catalyst in the reactor becomes coated with carbon from contact with the oil vapors, and this carbon deposition is almost immediately diffused throughout the catalyst bed."

The fluid catalytic cracking process serves quite

well as an example of fluidized solids technique because it illustrates most of the principles of this "unit operation." Basically, two chemical reactions must be considered here. The first, the cracking reaction, is an endothermic process adsorbing large quantities of heat and at the same time depositing carbon on the catalyst surface. This carbon is removed by a second chemical reaction, namely, simple oxidation of carbon by air, known in catalytic cracking as "regeneration" of the catalyst. This regeneration, of course, is highly exothermic. The combination of these two reactions is ideal for application of the fluid technique, for by circulation of fluidized catalyst from the zone of one reaction to the other, the heat liberated by the oxidation step can be utilized by the cracking reaction with high heat economy.

The principle of the catalyst in catalytic cracking is, of course, the acceleration of the chemical processes of cracking to such a degree that the reaction may be carried out at relatively low temperatures and to guide the reaction in the preferred direction. At these temperatures, which are 100-200° F. below those used in thermal cracking, the losses of oil through gas, coke and tar formation are greatly reduced and high yields of the desired liquid products are obtained. Furthermore, at low temperatures the quality of these products is greatly improved so that the octane number and stability of the gasoline is exceptional.

In the fluid cracking process, however, the catalyst has other functions resulting largely from its efficiency as a heat transfer medium. In the cracking zone the violent turbulence of the circulating catalyst effects a remarkable uniformity of temperatures in that zone which permits close control of the cracking reaction. The same is true in the regenerator. Furthermore, the high heat capacity of the tremendous circulating stream, 40 to 50 tons of catalyst per minute, results in the transfer of the heat of burning to the cracking zone to sustain the cracking reaction.

"A typical catalytic cracking plant is, of course, a highly complicated affair, but the process which goes on within it is comparatively simple. As far as the transformation from crude oil is concerned, the essential elements are the reactor and the fractionator. As in other cracking plants, the feed stock is heated before entering the reactor. It is cracked within the reactor and passes on to the fractionator where it is separated into gas, high octane gasoline, heating oil, and gas oil.

"It is in the reactor, in the presence of a fluidized catalyst, that the conversion of oil to a high yield of high quality products takes place. A rapid transfer of heat takes place when hot catalyst joins the pre-heated oil. Flash vaporization produces the oil vapors which transport the catalyst into the reactor. In the dense bed of seething catalyst, heavy oil is converted into high yields of high quality products. In the process carbon is deposited on the catalyst. A small part of the catalyst, carried overhead with escaping cracked vapors is almost completely recovered in cyclone separators and returned to the catalyst bed. A still smaller fraction of the catalyst escapes from the cyclone and is recovered as a heavy oil slurry at the bottom of the fractionator. This recovered oil and catalyst are pumped back to the reactor.

"As the cracking proceeds, the catalyst becomes contaminated with carbon, which lowers its activity. The carbonized catalyst, accumulated at the bottom of the reactor, after stripping of entrained oil vapors,

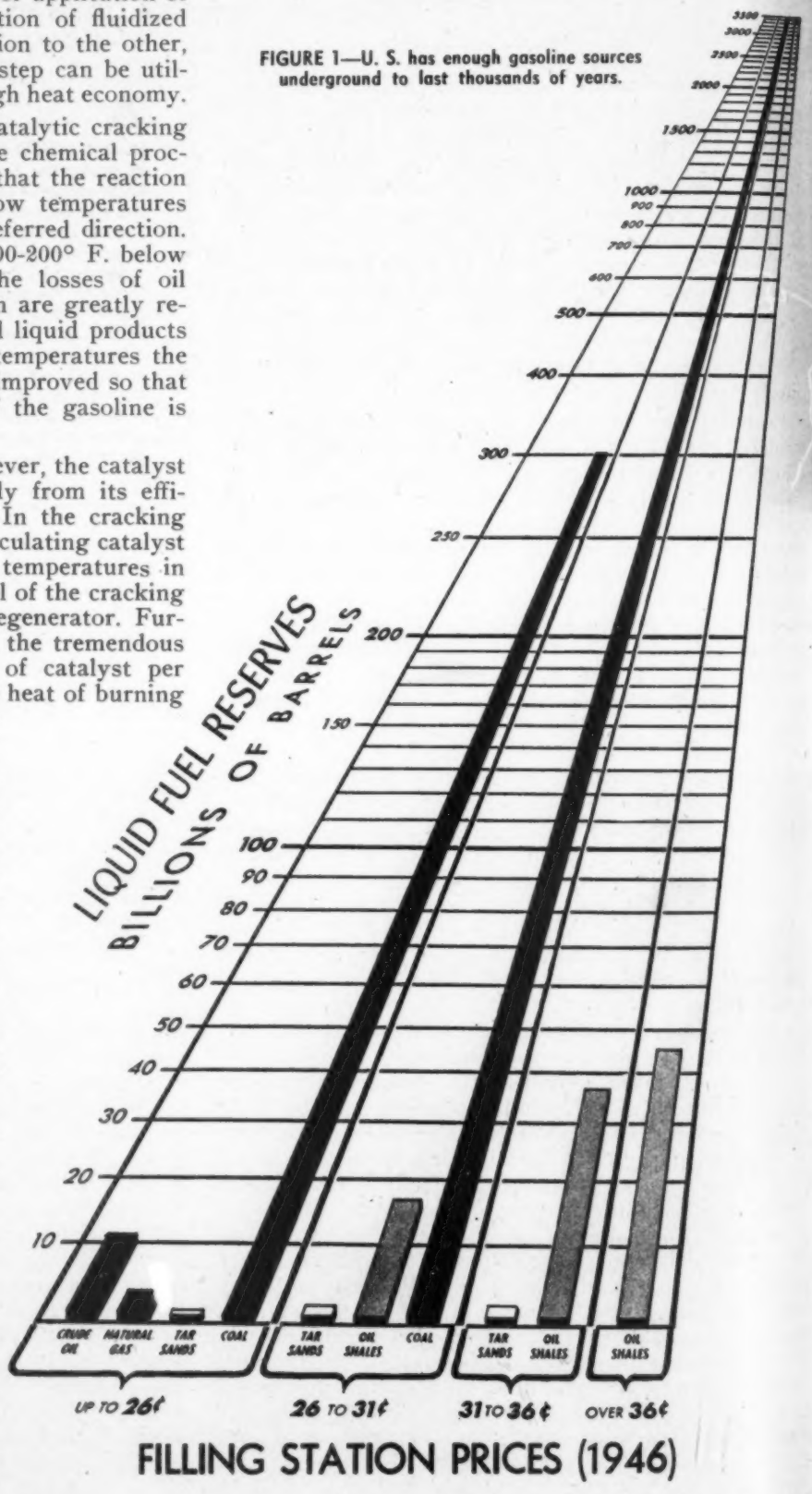
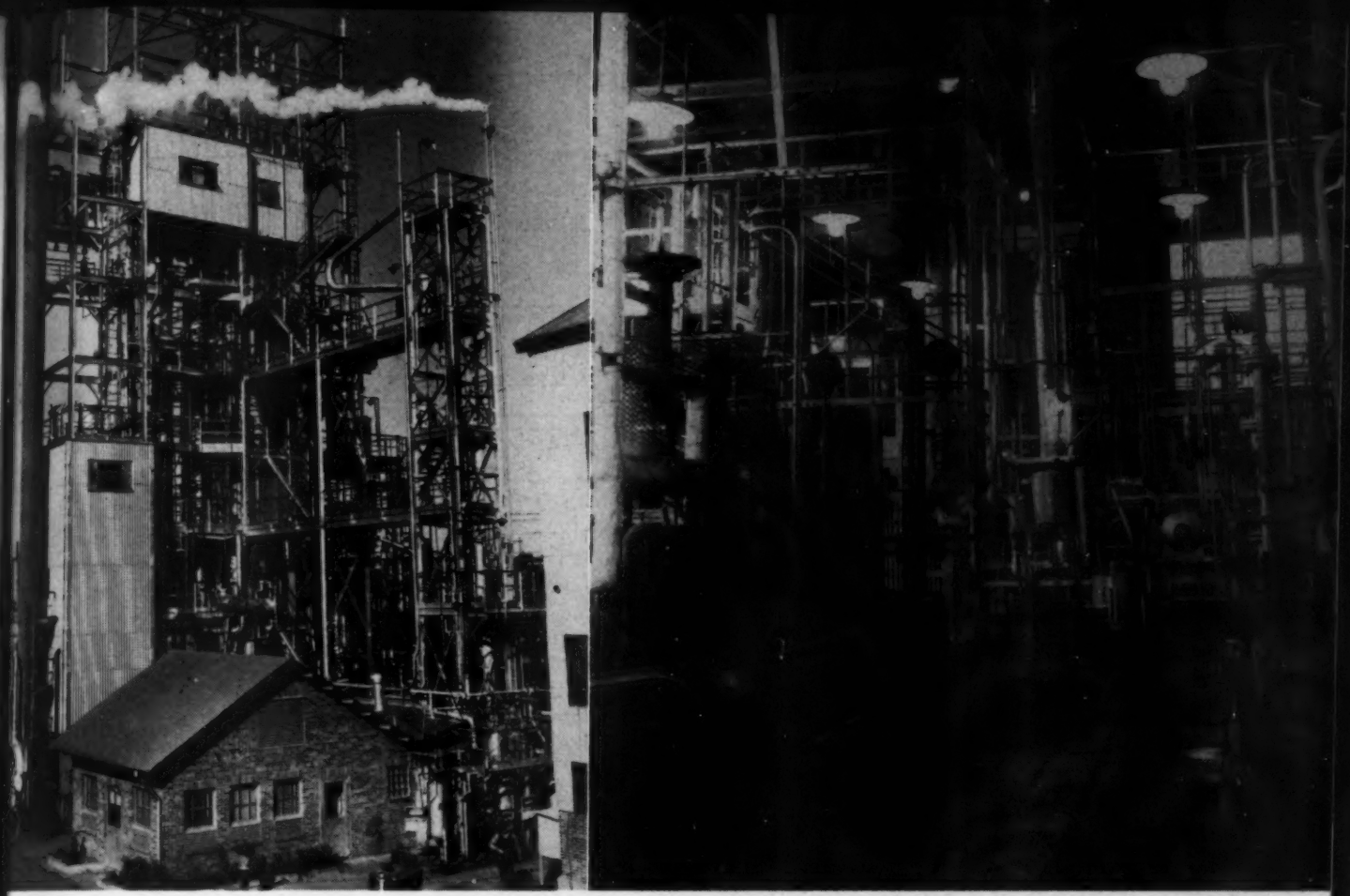


FIGURE 1—U. S. has enough gasoline sources underground to last thousands of years.



Left—Five-to-Ten Barrel-Daily Catalyst Hydrocarbon Synthesis Pilot Plant, Esso Laboratories, Baton Rouge, La. Right—Small Hydrocarbon Synthesis Pilot Units at Baton Rouge.

is withdrawn continuously through a slide valve, picked up with compressed air, and, as in an air lift, is blown upward, into a regenerator where the accumulated carbon is burned off. The seething bed of clean catalyst in the regenerator, operates at some 1100° F., a dull red heat. The violent action in the fluid bed gives some remarkable results. In a plant scale regenerator, as much as 200-million Btu's per hour may be liberated; yet the temperature in the regenerator seldom varies more than 5° F. from top to bottom, even though the catalyst bed may be 20 feet deep and up to 45 feet in diameter.

"The heat of combustion is stored in the catalyst and is imparted to the oil at the point of regenerated catalyst-fresh oil contact. The products of carbon combustion pass out of the regenerator through cyclone separators from which most of the entrained catalyst is returned to the fluid bed. The off-going gases go to a waste heat boiler and on to an electrical precipitator which removes most of the last traces of catalyst. Flue gas is vented from a stack at the precipitator outlet. The final recovered catalyst is repressured in a standpipe and passed by airlift to the generator.

"Regenerated catalyst flows down a standpipe to be picked up by incoming oil. Because of its fluid condition, a pressure head is developed by the catalyst in the regenerator standpipe. This pressure is sufficient for the catalyst to flow from the regenerator (a zone of relatively low pressure—through the regenerator slide valve into the reactor (a zone of relatively high pressure). Here the catalyst promotes the cracking reaction, after which it is discharged continuously from the bottom of the reactor. After leaving the reactor slide valve, it is carried by air stream back to the regenerator. In the fluid catalytic cracking cycle, there are no moving mechanical parts in the basic catalyst flow system. The major transformation of the entering oil molecules takes place in about 20 seconds, and the average catalyst particle makes its way around the circuit every ten minutes, yet the process runs continuously for months on end.

"In a typical commercial unit, catalyst is circulated through the cycle at a rate of some 40 tons per minute. Catalyst recovery is so complete that only about 0.005 percent of the 60,000 tons circulated daily is lost to the air, namely 2 to 4 tons per day."

Hydrocarbon Synthesis

Before the war, U. S. oil consumption was 3.8 million barrels per day compared to a production capacity of 5 million. The present consumption is 5.7 million barrels per day, and there is every indication that the demand will continue to increase rapidly. It is predicted[1] that by 1949 the world oil consumption will be 10 million barrels per day and that foreign consumption should increase even more rapidly than U. S. through rapid mechanization. It is not strange that the petroleum industry has been actively looking, since before the war at other sources of liquid fuels. The recent proposal of Secretary Krug that Congress spend $9-billion in the next 5 to 10 years for plants to produce 2 million barrels per day of synthetic oil is undoubtedly largely in the interests of national defense, but the plan invites the examination of many factors. The most concrete interest is, of course, in the two commercial plants for the syn-

thesis of gasoline from natural gas that are now under construction in Texas and Kansas.

Fortunately for us, our reserves of other sources of liquid fuels are vast. In addition to the natural gas already mentioned, we have shale oil, tar sands and coal. To illustrate the magnitude of these reserves, Figure 1 is presented. Also shown are the filling station prices (based on 1946 prices and cost estimates) which we might expect to pay before some of these sources could be tapped economically. It will be noted that, assuming about one-quarter of the natural gas reserves might be available for conversion to liquid fuels, petroleum reserves could be extended 30-40 percent by conversion of this natural gas to oil. When prices are increased sufficiently for coal conversion to be economical, however, we can count on reserves so vast that one-half of them would supply the present oil demand for 1000 years. This figure is of course limited in accuracy to that of the coal reserve estimates. Large additional reserves of shale and tar sands may also come into the picture.

Several Processes Available

To manufacture liquid fuels from these three raw materials several processes may be used. With natural gas the fluid catalyst adaptation of the Fischer-Tropsch synthesis is the most likely. To use this process the natural gas must first be converted to hydrogen and carbon monoxide by an oxidation step. Direct oxidation with pure oxygen is to be used in the two plants now being built. Synthesis of oil from coal may also take the Fischer-Tropsch route. Coal will first be converted to hydrogen and carbon monoxide and it is quite possible that a fluidized solids technique will be used for this step. The hydrogenation of coal to liquid fuels is also being investigated by the Bureau of Mines. It is this process which furnished the Germans with most of their synthetic fuel during World War II. Shale distillation has been developed satisfactorily through a small pilot plant stage as a fluidized solids process.

In the hydrocarbon synthesis process the basic raw material can theoretically be any carbonaceous matter, natural gas, coal, saw dust, agricultural wastes or even low grade oils. Any of these materials, however, must first be converted to hydrogen and carbon monoxide by combination with oxygen, steam, or carbon dioxide. After these gases are manufactured, the treatment to form liquid fuels is the same regardless of the primary raw material. Inasmuch as the simplest and cheapest starting material is natural gas, the petroleum industry has started its development of hydrocarbon synthesis with that raw material. Fortunately, some of the knowledge gained through this development can be almost directly applied to the more complicated process starting with coal.

There are two important methods of converting natural gas to hydrogen and carbon monoxide. The first, used for many years in the ammonia synthesis industry, consists of reforming the methane with steam over a nickel catalyst at temperatures in the region of 1500° F. To adjust the ratio of hydrogen to carbon monoxide to that desired for synthesis, carbon dioxide is added. To give a 2- to 1-ratio the proportions are as shown in the following equation:

$$3CH_4 + 2H_2O + CO_2 = 8H_2 + 4CO$$

3 Volumes Nat. Gas = 12 Volumes Synthesis Gas

The development of the new low cost oxygen has made possible a more simple method of generating synthesis gas, the direct oxidation of methane with oxygen. This process takes place in a simple combustion chamber without benefit of catalyst and has the big advantage that synthesis gas can be manufactured under the pressure at which it will be used in the synthesis reaction itself thus reducing the high compression costs.

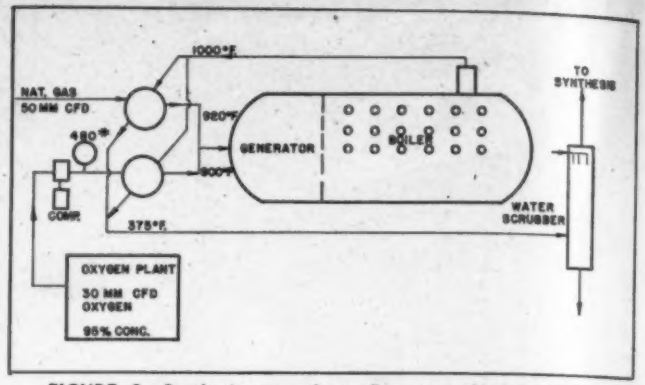


FIGURE 2—Synthesis gas plant—Direct methane oxidation.

A flow sheet for a synthesis gas generation plant using natural gas and oxygen is shown in Figure 2. It has been reported that a 50-million cubic foot daily flow of natural gas is preheated by heat exchange to 920° F. where it is mixed with a similarly preheated stream of 30-million cfd. of oxygen. These gases burn in a refractory lined generator at about 2500° F. and under synthesis pressure, in the range of 300-600 psig. The gases are quickly cooled by a bank of boiler tubes to 1000° F. thereby generating high pressure steam. Further cooling is effected by heat exchange with the incoming gases. The quantities of gas involved in this generator should be sufficient to produce almost 5000 barrels of oil daily.

Pilot Plant Work Under Way

Details of the manufacture of synthesis gas from coal are not so well worked out although pilot plant work is under way. Standard Oil Development Company, together with Pittsburgh Consolidated Coal Company, are erecting a complete gasification pilot plant at Library, Pa., which will also use the fluidized solids technique. As with natural gas, it is necessary to convert the coal to hydrogen and carbon monoxide by partial combustion. This may be accomplished by the use of pure oxygen, with steam added to increase the hydrogen to carbon monoxide ratio. It is the belief that almost any grade coal may be used and that mechanical mining methods will be improved which will bring the coal out of the earth at a low cost. Of course, the possibilities of gasifying coal underground are also being explored as another source of synthesis gas.

"The synthesis of hydrocarbons from hydrogen and carbon monoxide is carried out in a reactor employing the fluid catalyst technique and which operates at 600-700° F. and at a pressure of 20 to 30 atmospheres. In the presence of an iron catalyst which is in constant and violent motion the synthesis gas reacts to form synthetic hydrocarbons and water. The reaction liberates a very large amount of heat, amounting to over 14-million Btu's per ton of liquid product produced. Cooling tubes immersed in the fluidized catalyst make possible high rates of heat transfer, while still maintaining uniform temperature throughout the catalyst. The heat of reaction is absorbed in

the vaporization of water to form high pressure steam which is a source of heat and power throughout the plant. The maintenance of an even catalyst temperature with this large heat evolution has been in the past the major difficulty in applying the synthesis operation to large scale production.

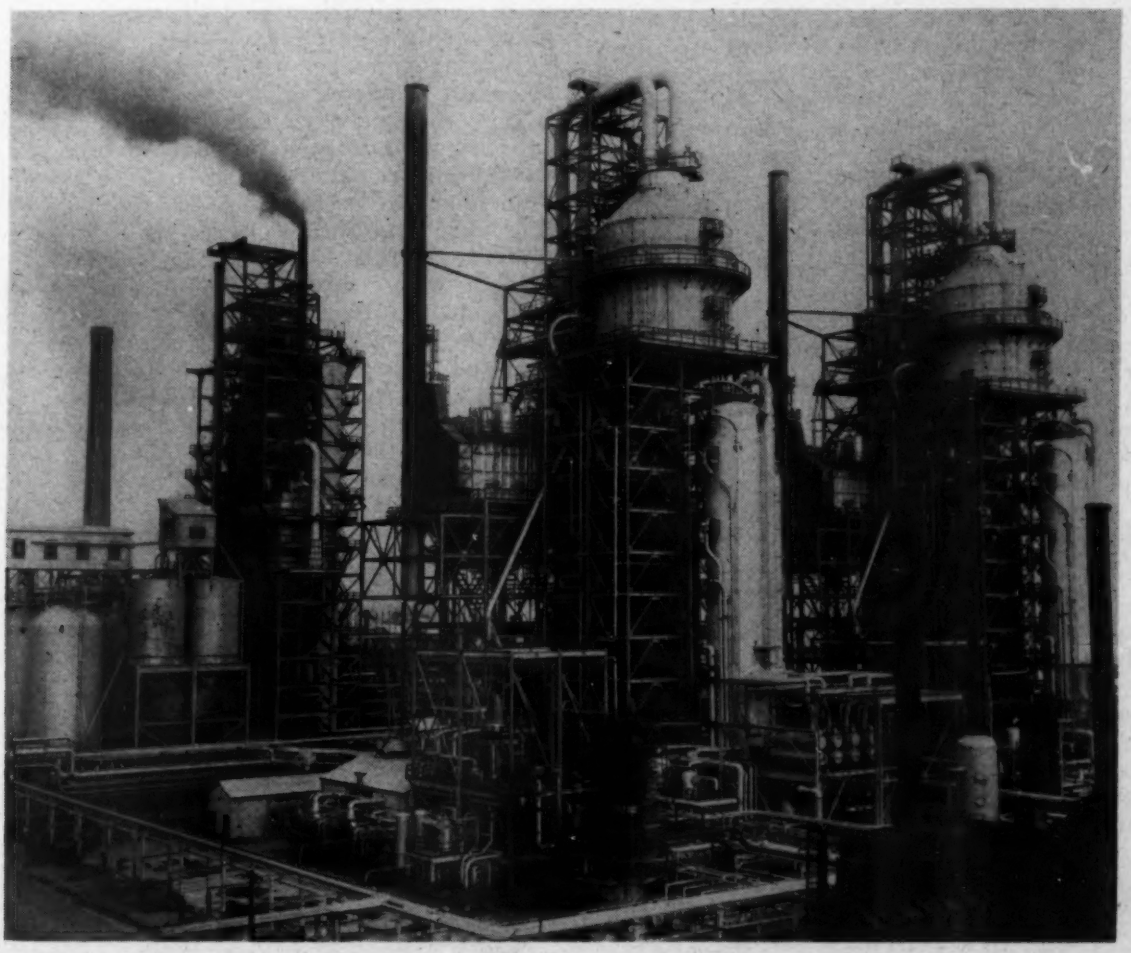
"A relatively deep bed of catalyst is employed in the synthesis reactor. Most of the small amount of entrained catalyst leaving the fluid bed is recovered in a cyclone and returned through a dip pipe to the catalyst bed. The synthesis product leaving the reactor is passed to a condenser. From the condenser it is passed to a receiver where the gases are separated from the liquids. A portion of the gas is recycled for further processing. From the remainder of the gas, light hydrocarbons are recovered. The residual tail gas is used to furnish plant heat and power requirements, or part of it may be sold as fuel. The liquid hydrocarbon products are primarily high octane gasoline and diesel oil which require only normal finishing treatment. By-products of the process include a variety of useful chemicals."

Germans Begin Synthesis Process

The hydrocarbon synthesis process began in Germany in 1923 with the discoveries of Fischer and Tropsch, and it was upon their discoveries that the German synthetic oil process was founded. Their process consisted of converting hydrogen and carbon monoxide in a ratio of 2 to 1 to heavy straight-chain paraffin hydrocarbons over beds of cobalt catalyst. Temperatures were low, around 400° F., and the pressure was atmospheric. The straight-chain paraffins resulting from this operation were of very low octane number, on the order of 10 to 40 ASTM. In fact, the Germans used this synthetic product largely for other uses, such as lubricating and diesel oil manufacture. It was, nevertheless, a large industry.

Work started actively in the United States about 1938 and, of course, first investigations closely paralleled the German work. Despite the stoppage of much of the U. S. research in that field during the war, it was not long before the search after higher octane gasolines led the U. S. workers to a different catalyst and an entirely different mechanical approach to the problem. By changing over to an iron catalyst, it was possible to increase the reaction temperature to a range of 600-700° F. This meant that the pressure also had to be increased to 20-30 atmospheres, but the resulting product was now highly olefinic with more branched-chain molecules—in other words, higher octane number.

The mechanical design of such plants centers around the removal of the high heat of reaction. The Bureau of Mines has developed a slurry process in which that heat is removed by the circulation of oil products. The industrial developments, however, are based on the fluidized solids technique. The simplification of equipment resulting from the use of fluidized catalyst is amazing. The Germans, in order to remove the heat of reaction and protect their sensitive catalyst from high temperatures, arranged the catalyst in very thin beds between cooling surfaces. For a plant producing 10,000 barrels daily, 6



Three Commercial Fluid Catalytic Cracking Plants, Esso Standard Oil Company, Baton Rouge, La.

million square feet of cooling surface would have been required.

The American fluid processes are planned with only ½ to 1 percent of that area per barrel per day capacity. As in most catalytic processes, close temperature control is still required both to protect the catalyst and to insure the proper yields of product. It is contemplated[2] that the catalyst to be used will be essentially pure iron derived from an oxide with some alkali promoter added. It has been reported that the source of oxide may be iron ores, mill scale, ammonia synthesis catalyst, the sinter from roasting sulfide ores, etc.

The mechanism of the synthesis reaction is not too well understood. The chemists would represent the reaction simply by the following equations:

$$2H_2 + CO = \frac{1}{n}(CH_2)_n + H_2O \qquad (1)$$

$$H_2O + CO = H_2 + CO_2 \qquad (2)$$

$$3H_2 + 3CO = \frac{2}{n}(CH_2)_n + H_2O + CO_2 \qquad (3)$$

(Addition of (1) and (2))

The first two reactions, the synthesis step and the water-gas shift reaction, can be added together in varying proportions. The third equation is a typical example. The ratio of consumption of hydrogen to carbon monoxide can be changed from 2 down to ½, but the yields of oil represented above by $(CH_2)_n$ from a given volume of the hydrogen and carbon monoxide mixture are not basically changed.

Normally, the products from synthesis will include a mixture of paraffins and olefins varying from the lightest gases, methane, ethane, ethylene, etc., up to heavy oils and wax. Also dissolved in the oil in the water layer are a host of chemicals, differentiated from hydrocarbons by the presence of one or two oxygen atoms per molecule. These oxygenated compounds include alcohols, aldehydes, ketones and acids. At the conditions at which Stanolind Oil and Gas Company proposes[3] to operate its hydrocarbon synthesis plant, the estimate of synthetic oil products, after treating to convert oxygenated compounds into olefins and to polymerize light olefins, are 84 percent gasoline, 11 percent distillate fuel and 5 percent heavy fuel. The finished gasoline will have a clear ASTM octane number of about 80. Standard Oil Development Company[2] has quoted the same ASTM octane number and a clear research octane number of about 93 which 2 cc. TEL will increase to 98. Of course, there will be some lighter hydrocarbons formed as by-products.

Chemicals from Synthesis Plants

Sullivan[4] has given us some interesting figures on the production of chemicals from 10 hydrocarbon synthesis plants of a nominal daily capacity of 7000 barrels each. These figures are compared in Table 1 with the present total U. S. production of these chemicals. The figures for hydrocarbon synthesis plants are calculated from the estimated production of organic chemicals from the Carthage-Hydrocol plant at Brownsville, Texas. The chemicals from these 10 synthesis plants amount to an average of 68 percent of the product now produced by the present U. S. organic chemical industry, varying from 26 percent for acetaldehyde to 87 percent of the present acetic acid production. It is evident that if the petroleum industry starts producing oil synthetically, it will immediately become also the major producer of basic organic chemicals.

TABLE 1

Annual Production of Important Chemicals by Ten Hydrocol Plants Compared with U. S. Production[5]

PRODUCT	Date (U.S.)	United States (1000 Lb.)	Ten Hydrocol Plants (1000 Lb.)	Ratio Hydrocol To U.S. Prod.
Acetaldehyde	1946	352,000	91,000	0.26
Acetone	1946	335,000	112,000	0.33
Ethanol	1943-45	830,000*	636,800	0.77
n-Propyl Alcohol	1946	141,000†	144,000	....
n-Butyl Alcohol	1946	126,000‡	43,700	0.35
n-Amyl Alcohol	1946	15,000	10,600	0.71
Acetic Acid	1946	285,000	247,000	0.87
Propionic Acid	....	.....	87,000	....
Butyric Acid	....	.....	42,000	....
Totals	....	2,084,000	1,414,100	0.68

* Excluding allocations to Acetaldehyde and Acetic Acid.
† Isopropanol excluding allocations to Acetone.
‡ Total Amyl Alcohols.

At the present stage of development and with the current uncertainty of construction cost estimates, the presentation of an accurate cost picture is difficult. Based on natural gas at 10 cents per thousand cubic feet, Murphree,[5] president of Standard Oil Development Company, has quoted a cost of gasoline from natural gas at 13 cents per gallon including amortization and return on investment. This can be compared roughly to a 14 cents per gallon price for gasoline from crude oil when produced in newly constructed equipment and when operating for maximum yield of gasoline. A similar price of gasoline from coal might be 16-17 cents per gallon and from shale, 16 cents per gallon.

The investment per barrel per day of oil products capacity for crude oil production, transportation to consuming area and refining is about $4300 for maximum distillate yield and $6500 for maximum gasoline yield and for oil synthesis from natural gas, $7400 and $8200 on the same basis. For synthesis starting with coal, $7600 and $8500 is estimated and from shale $6100 and $8400. With coal and shale product transportation is not included which may be required in areas west of the Mississippi. High housing costs, also must be added for such a location.

It is evident from these figures that construction costs play a large part in determining the price of synthetic gasoline. Despite these high costs, however, the average motorist need feel little concern over the future supply of gasoline for his automobile, for even at the present stage of development of the gasoline from coal process, estimates show that it will cost him only 10-15 cents per day more to operate his car on gasoline from coal than he now pays for petroleum gasoline.

AUTHOR'S NOTE

Portions of this paper, shown in quotation marks, were adapted from an address by R. P. Russell, "Trends in Petroleum Refining." Acknowledgment is hereby gratefully made.

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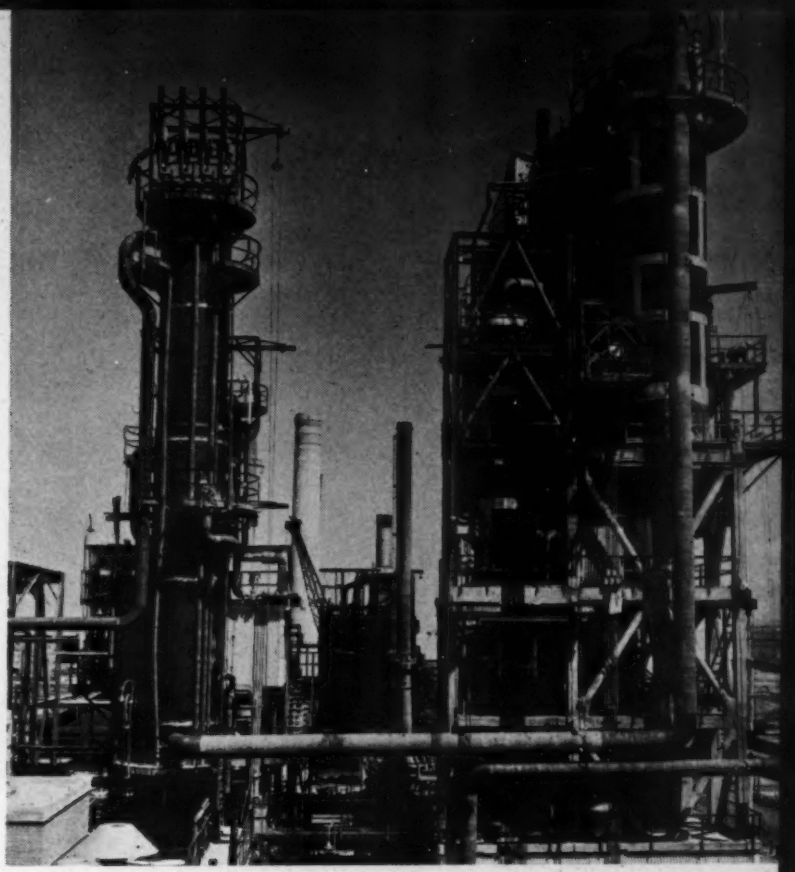
* * *

Casper Plant Called Model of Small Refinery Planning

THE Casper, Wyoming, refinery of The Texas Company, by the addition of a modern fluid catalytic cracking unit, is deservedly acknowledged a model of small refinery planning. Charging 4500 barrels daily of gas oil (500 barrels more than the design rate) from the 10,000 barrels of Wyoming crude oil processed daily by the refinery, the unit represents a milestone in the process design and construction of fluid type catalytic cracking units for use in the small refinery. Plant production is marketed in the Rocky Mountain area.

Of interest to operating and process engineers is the basic design of the new unit, which is the first to utilize "balanced pressure" design. The unit circulates five tons of catalyst per minute from a normal inventory of 70 tons. Conversion at present operation is approximately 58 percent, and catalyst to oil ratio about 12 to 1.



Above photograph shows west view of the "cat" showing fractionator at left, reactor at right, with the new outside stripper between the two. Note the direct pipe run from top of reactor to base of fractionator. Overhead vapors from fractionator leave by pipe line descending tower at left.

THE fourth unit added to the Casper, Wyoming, refinery of The Texas Company, one of the latest type fluid catalytic cracking units, is on stream and charging 4500 barrels per stream day of gas-oil from the 10,000 bpsd of Wyoming crude oil processed by the refinery. Initial design of the fluid unit was for a charge rate of 4000 bpsd. Including the fluid catalytic cracking unit, the processing facilities of the refinery consist of a 10,000 bpsd. combination crude and vacuum unit, a thermal reformer, a catalytic polymerization unit, and a pressure coke still for thermal cracking.

The new fluid catalytic cracking unit incorporates the latest engineering improvements aimed at obtaining the highest over-all economy in design and operation of the process. One of the most apparent changes in design is the arrangement of vessels in the supporting structure, which has substantially reduced the elevation of the unit, simplified piping, and brought the "balanced pressure" method of operation into use. The balanced pressure design permits the reactor and regenerator to be placed side by side at the same platform levels in the supporting structure, as shown in the aerial view of the unit. This change in position is due to the fact that catalyst circulation is accomplished by pressure differentials.

For example, if the catalyst circulation system is

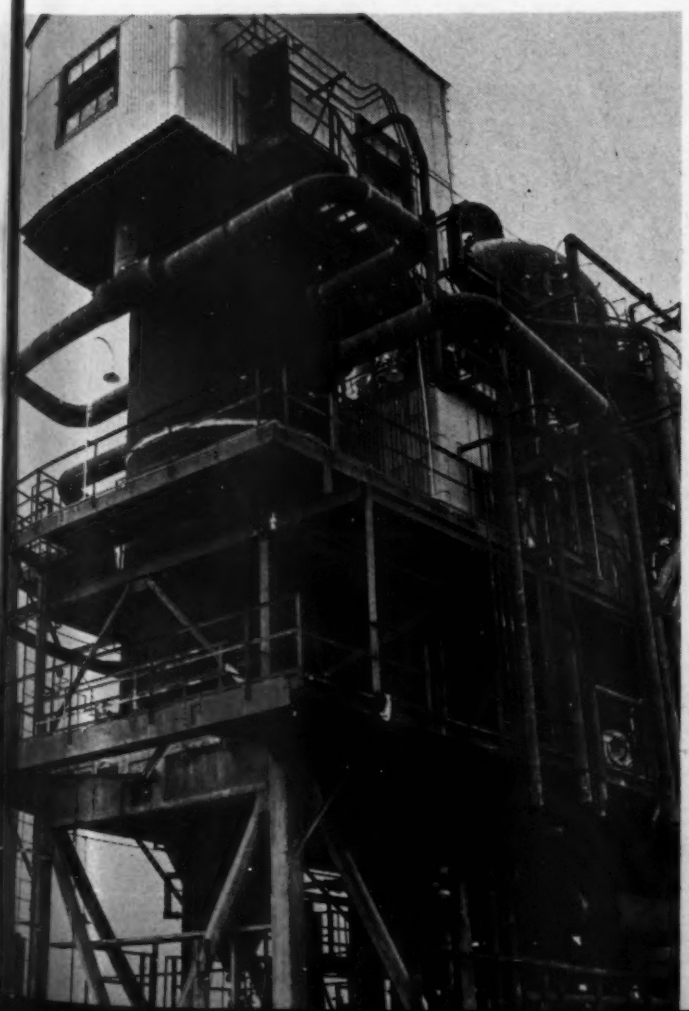


Photo at left shows the new cylindrical precipitator for recovery of catalyst. Hot flue gases from the regenerator (which have just been cooled, making steam) enter via the two bottom lines and leave via the two top lines. Recovered catalyst falls to the base of the vessel and is returned to the regenerator in a current of air. The little "house" at the top is the electrical substation for the precipitator.

Photo at left shows top of regenerator immediately after refractory was dried with hot air at 900° F. The two cyclone separators in parallel prevent small catalyst particles from escaping with the flue gasses. Recovered catalyst is returned to the main regenerator bed via the dip pipes shown.

considered as two similar parts—regenerated catalyst flow to the reactor, and spent catalyst flow to the regenerator—flow requirements for either part can be described in terms of pressure differentials existing on the upstream and downstream sides of the respective slide valves. Considering the flow of regenerated catalyst to the reactor, pressure components on the upstream side of the regenerated catalyst standpipe slide valve include the vapor pressure above the regenerator catalyst bed, the fluid head of the catalyst bed, and the fluid head of the regenerated catalyst standpipe.

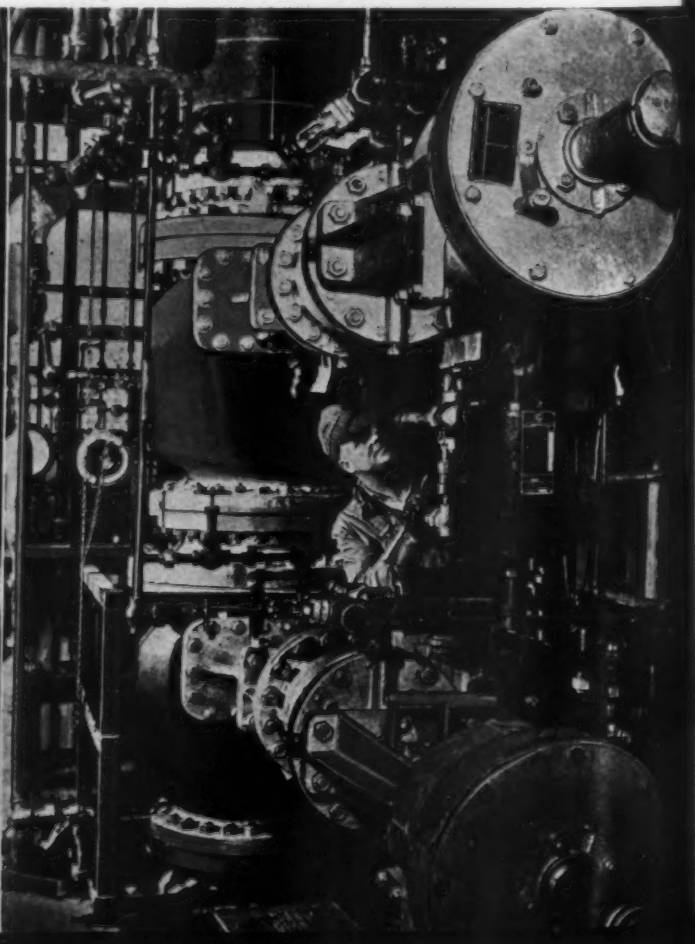
Pressure components on the downstream side of this same slide valve include the reactor pressure, the fluid head of the reactor catalyst bed, pressure drop across the reactor grid, the fluid head of the dilute phase oil vapors and regenerated catalyst in the reactor feed line, and friction pressure losses in the reactor feed

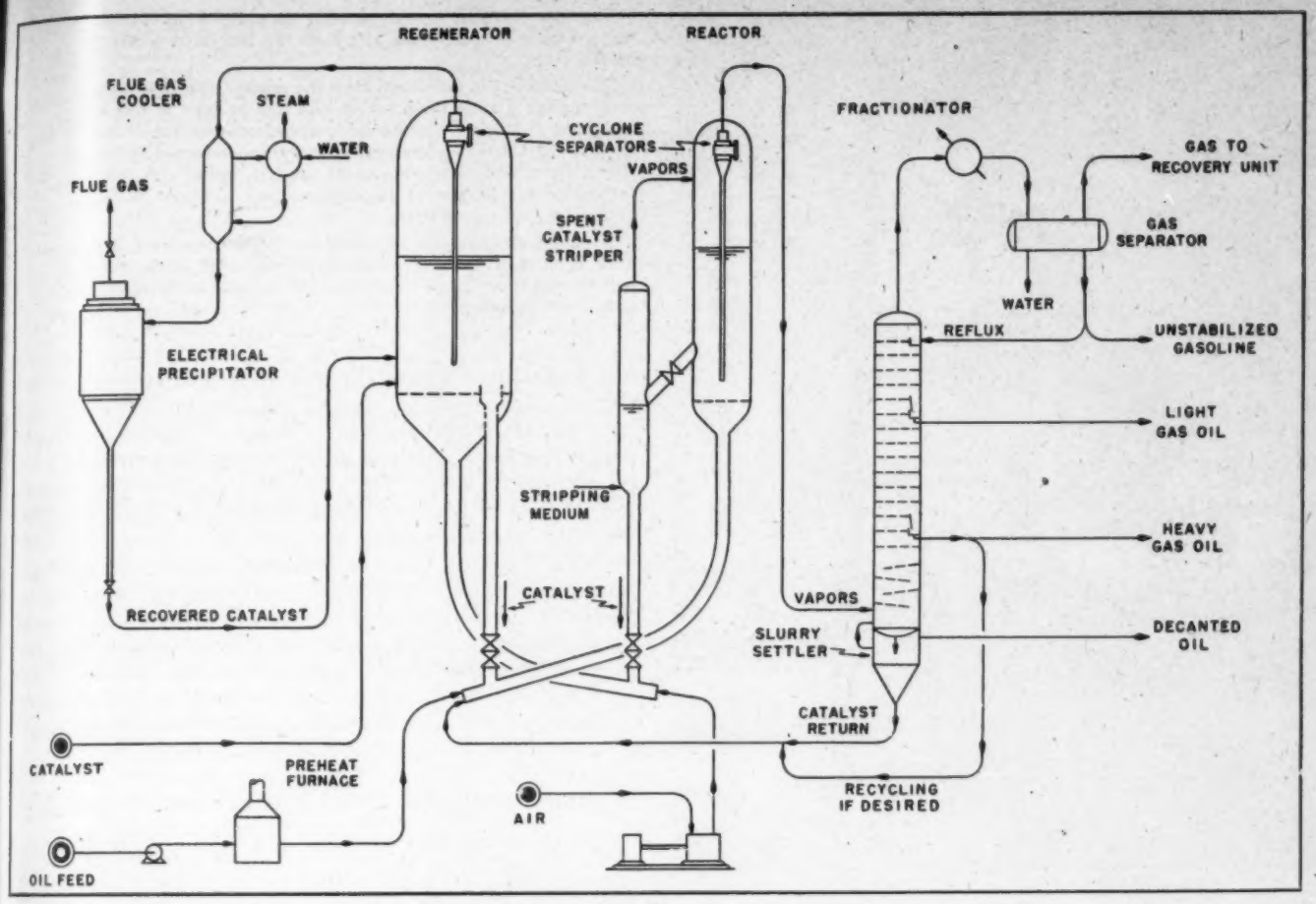
Photo below pictures workman looking up at burner flame of air heater through a sight glass. Ordinarily, it is not necessary to preheat the air used in the unit as the heat generated elsewhere in the process is sufficient to meet all requirements. However, in starting a cold unit up, the interior of the regenerator is first heated to about 1000° F. with hot air obtained by blowing air through this heater. The air heater is designed to use either a gaseous or liquid fuel.

The two slide valves of the regenerator standpipe with the hydraulic valve positioners in the foreground are shown in the picture below.

In normal operation, hot (1100° F.), regenerated catalyst passes down the regenerator standpipe through these control mechanisms, on its way to flash vaporize the gas oil feed to the Fluid unit. The gaseous mixture of oil and catalyst then flows to the reactor where cracking to high-test gasoline is completed.

Two slide valves are provided for controlling the rate of catalyst flow; normally the top one is in wide-open position on a stand-by basis while the bottom one only is used for control. Should it fail to function properly for any reason, the top valve would be switched to the control position and a costly unscheduled shutdown thus avoided.





Typical Flow Sheet of Fluid Catalyst Cracking Unit.

line. For flow to occur across the slide valve, it is evident that the total of upstream pressure components must exceed the total of the downstream pressure components. In actual practice the slide valve is operated to absorb the excess pressure differential and serves thus to control the catalyst circulation rate. The flow of spent catalyst to the regenerator is a similar case, with combustion air substitued for oil vapors as the dilute phase carrier medium.

The relative densities of dense phase catalyst flow in standpipes and of dilute phase flow in reactor feed line and spent catalyst carrier line, obviously are responsible for the difference in slide valve upstream and downstream pressures, and make the whole catalyst circulation system operable. Many varying combinations of reactor and regenerator pressures, catalyst bed depths, and standpipe lengths can be worked out that will provide the necessary positive pressure differential across the slide valves.

Obviously, variation of the component pressures permits wide variation in the relative elevations of reactor and regenerator. There are a number of factors, however, in addition to maintaining fluidized catalyst flow, that affect arrangement of the vessels for commercial operation. Optimum operating pressure, low first cost, and ease of maintenance requirements have pointed the way to development and use of the balanced pressure design. This method permits the regenerator and reactor to operate at low and practically equal pressures. Operation at low reactor pressures results in less carbon formation and higher quality gasoline, while low pressure in the regenerator minimizes catalyst deactivation and reduces utility costs.

A second improvement in the design of the Fluid catalytic cracking unit constructed at Casper is in the equipment used in catalyst recovery. Entrained particles of catalyst in the gases leaving the regenerator are recovered in cyclone separators and a precipitator. Vapors leaving the reactor are passed through cyclones and scrubbed in the base of the fractionator, after which catalyst fines in the scrubbing oil are recovered in a slurry settler or separator built into the base of the fractionating column. Since catalyst cost is not inexpensive, equipment for its conservation—cyclones, precipitator, and slurry settler—is economically justifiable due to the savings in catalyst replacement. The daily loss is less than 0.003 percent, or 30 parts per million of the circulated solids.

Cyclone and Electrical Precipitators

Cyclone separators of the type used in this unit have a long record of satisfactory operating results in recovering coarse catalyst. These units are mounted in the vapor space of the reactor and regenerator, and all vapor leaving the vessels flows through them in a high velocity spiral path. Catalyst particles, heavier than the entraining gas stream, are thrown to the outside of the cone by centrifugal force, collected, and returned to the vessels' turbulent bed through a dip-pipe included for that purpose. Low pressure drops, obtained by designing equipment for moderate gas velocities wherever possible reduce erosion and abrasian in the cyclones.

The catalyst fines in the regenerator flue gases, too light to be recovered by centrifugal force in the cyclone separators, are recovered in a specially de-

The new, exterior, spent catalyst stripper—first catalyst stripper built as a separate unit from the reactor is pictured at the left.

Spent catalyst is withdrawn from the reactor at a controlled rate through a slide valve (which can just be seen to left of mid-point of stripper). In the stripper, hydrocarbon vapors are separated from the catalyst with steam and returned to the top of the reactor, while the spent catalyst, laden with coke, falls from the bottom of the stripper and is blown to the regenerator for reactivation.

Stripping efficiency is increased by this arrangement and all possibility of the stripped vapors being picked up by more spent catalyst or "short-circuiting" (using spent catalyst over again) is eliminated.

signed electrical precipitator. A negative electrostatic charge is induced on the particles of catalyst as they flow through the precipitator in the flue gas stream between two electrodes. A high voltage is maintained across the electrodes and the catalyst fines are attracted to the positive or collecting electrode. The fines are dropped to the base of the precipitator and then blown back to the regenerator.

The electrical precipitator is of new design—a shop fabricated pressure-tight cylindrical shell, which operates at a higher pressure than the precipitators of earlier units. Catalyst recovery in the precipitator of the unit was guaranteed at 98.4 percent; however, better than 99 percent of the fines are expected to be recovered.

Catalyst fines also enter the base of the fractionator in the reactor effluent stream and are diverted into the fractionator bottom stream by a scrubbing system of baffle plates. Return of this bottom stream to the reactor would provide full recovery of fines, but it also would decrease the efficiency of the process, because the bottoms are the heaviest oils produced and have a high resistance to further cracking, resulting in higher coke yield and requiring greater regenerator combustion capacity.

To reduce the amount of bottoms that must be returned to the reactor, an integral slurry settler has been built into the base of the fractionator. In the settler, catalyst fines gravitate to the bottom at tower pressure and are returned to the reactor with only a small amount of bottoms. Meanwhile, decanted oil is withdrawn from the top of the slurry settler for further processing by thermal cracking, or for use as a fuel oil. This design eliminates use of a separate vessel, or moving parts, and provides greater safety in operation.

An outside spent catalyst stripper of new design has been incorporated in the unit to recover the entrained and absorbed hydrocarbon vapors in the spent catalyst from the reactor. Use of an outside stripper promotes high catalyst activity and better stripping efficiency. Except for the stripper, these vapors would enter the regenerator and be burned, thus wasting valuable materials and increasing the combustion load of the regenerator, requiring a larger regenerator and increased air blowing equipment. Since the throughput of the unit is directly dependent on the coke-burning capacity of the regenerator, the importance of efficient operation of the outside stripper is obvious. Steam enters the base of the stripper, strips the hydrocarbon vapors from the catalyst, and carries them into the vapor space of the reactor.

Unit Flexibility—Feed Preheat and Recycling

The Casper unit is designed with a preheat furnace to raise the total heat of the feed and provide greater operating flexibility with respect to the control of the conversion level, and lower catalyst-oil ratio. The preheat furnace provides additional heat input to the reactor independently of the heat from the combustion of coke in the regenerator, which enables the unit to function with high efficiency even though amount or type of feed stock varies, or the market requirements differ.

Currently, the Fluid catalytic cracking unit is operating with about a 58 percent conversion. In Table 1, the yields from charging 4327 bpsd with this conversion level resulted in 1820 bpsd of 400 endpoint gasoline.

Operation of the unit at a higher single pass conversion level would result in wasting feed stock by production of high yields of coke and dry gas; however, to produce higher yields of gasoline per barrel of charge stock, the unit is designed for recycling a portion of the fractionator heavy gas-oil stream to the reactor with the catalyst fines for increased oper-

TABLE 1
YIELDS TABLE
Fluid Cat-Cracking Unit
The Texas Company, Casper, Wyoming

Fresh Feed Rate, bpsd	4327
Fresh Feed Gravity, °API	27.5
Reactor Temperature, °F	900
Products	
Debutanized, 400 EP Gasoline, bpsd	1820
Light Cycle Gas Oil, bpsd	650
Heavy Cycle Gas Oil, bpsd	1160
Catalytic Polymerization Charge (Mixed C_3's and C_4's), bpsd	950
Gas Oil Conversion, percent	60
Coke Burning Rate, lbs./hr.	3000

From the 950 barrels of light gases produced in the catcracker, a final yield of 350 barrels of catalytic polymer is obtained in the catalytic polymerization unit.

This polymerization has been very successful to date, conversions of 80 to 90 percent of the olefins being obtained at a catalyst life of 80 gallons per pound. Kellogg Polyco catalyst is used.

Top photograph—The unit is so completely equipped with automatic control instruments and alarms that, once started, continuous operation is possible without ever leaving this Control Room.

The slurry reflux pump, largest on the unit, handles up to five times the volume of fresh feed. The operator is pictured in the center photograph opening the exhaust steam line of the turbine driver.

It is necessary to remove heat from the base of the fractionator because the hot reactor gases contain more heat than is required for their fractionation. This pump therefore circulates the hot slurry from the base of the fractionator through a boiler where it is heat exchanged with water, making steam which is used elsewhere on the unit.

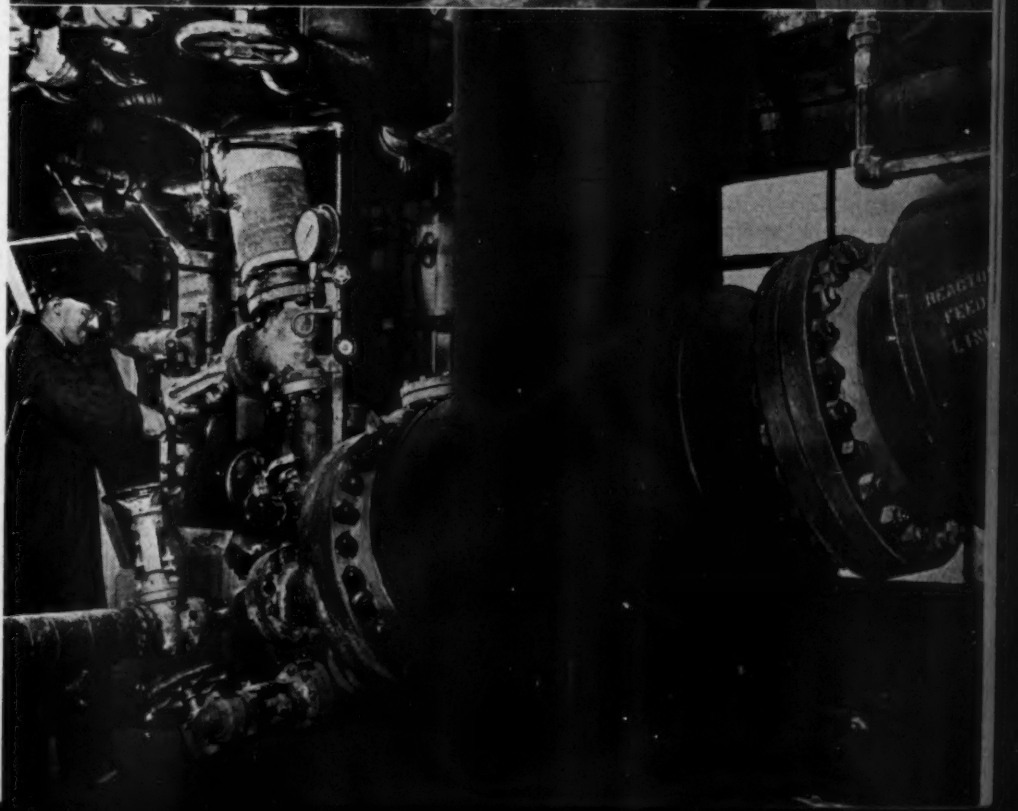
The "Christmas tree" of valves and piping on the pump is to distribute cleaning and flushing oils continually to the inlet and outlet of the pump.

ating efficiency. By this method, the unit can convert up to 75 percent of the charge stock into desirable light products without waste due to over cracking.

Increased knowledge concerning catalyst loading in lines, erosion prevention and optimum gas velocities has resulted in improved piping and valving for anticipated high stream efficiency in the unit. Catalyst carrier lines are designed for smooth flow at low velocities—sharp bends have been eliminated, piping carefully sized and arranged so that only one expansion joint is required. The flow of catalyst through the system is controlled by the hydraulically operated slide valves specially designed for erosion resistance to flowing powder. These valves, though built for heavy duty, are simply operated. The useful life of the valves has been substantially lengthened by reduced catalyst velocities through the ports. By installing two slide valves in series in the standpipe lines, one controlling catalyst flow and the other in wide open position as a standby, higher stream efficiencies are provided through insured controllability of the catalyst flow on long continuous runs.

ACKNOWLEDGMENT

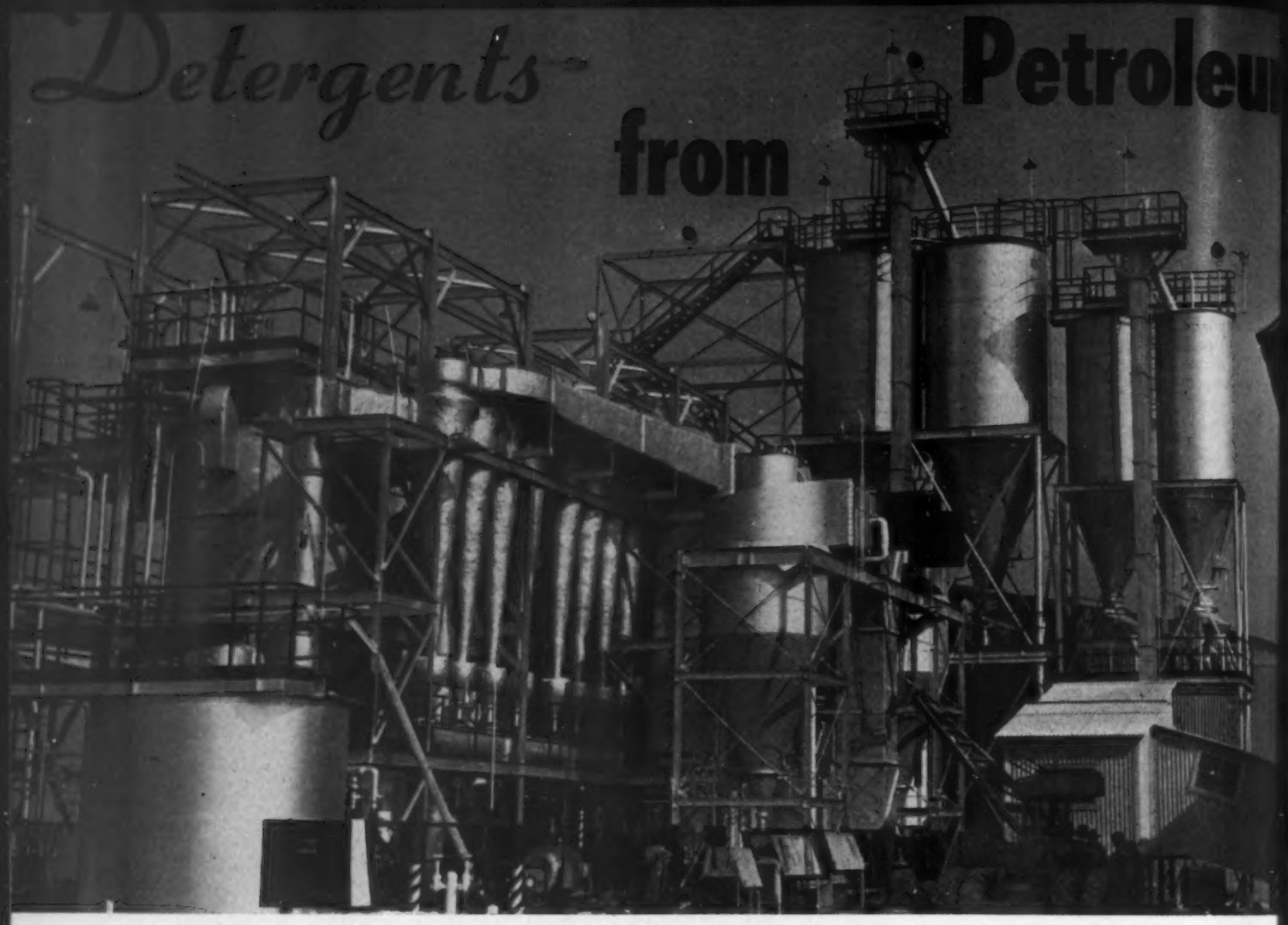
The cooperation and assistance of The Texas Company and The M. W. Kellogg Company in preparation of this article is hereby acknowledged.



The lower photograph shows the reactor feed line at its junction with feed injection point and regenerator standpipe. Fresh, preheated gas oil, catalyst slurry, recycle oil and dispersion steam all enter the reactor feed line at the left where they are immediately contacted by hot regenerated catalyst. The oil is flash vaporized and flows with the catalyst and steam into the reactor where cracking is completed.

In the photo, an operator is opening oil feed gate valve.

Detergents from Petroleum



Alkyl aryl sulfonate detergent drying plant at the Richmond Refinery, Standard Oil Company of California. While large-scale production of detergents from petroleum requires considerable equipment, economies are such that these detergents will offer considerable competition to soap even when fats and oils are again cheaper.

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BEFORE considering specific materials, it would be well to consider the nomenclature of the detergent field, especially since the terms involved are often misused in practice. In the broadest sense, a detergent is simply a cleansing agent, and it has been pointed out that water alone can be used for this purpose, if enough time is taken and enough scrubbing done; the riverside rock pounding of clothes by primitive peoples is testimony to this fact. Cleansing agents, however, can be used to speed the process greatly by reducing the interfacial tension between the "soil" and water "to a point where the solid dirt or oil particles are displayed by the solution";[32] to be a good detergent, incidentally, the agent must also "be soluble to some extent in water; it must lower the surface tension of the water, allowing the latter to penetrate the capillaries of the fiber and to wet them (in the case of fabrics)," and, after the "solid dirt or oil particles are displaced by the solution, it must "emulsify such displaced dirt or oil and hold it in solution."[32]

As can well be understood, not all "surface-active agents" satisfactorily fulfill all of the above requirements, hence ought not to be classified as real detergents. Some "wetting agents" or "penetrants," for example, fail to emulsify the "soil" or to hold the emulsified soil in suspension. "Foaming agents" and "emulsifying agents," also, are not necessarily good detergents. Such compounds have their own specific uses, but their similarity in structure to real detergents if often such that they are classed with detergents in production statistics and lists. In the case of the synthetic surface-active agents, this is readily understandable when it is noted that simple variation of the length of the hydrocarbon chain will produce, in a given "family," compounds of which some are detergents and some are simply wetting agents, emulsifying agents, etc. Therefore, although this article will deal chiefly with detergents, related compounds cannot be ignored completely.

Detergents, in general, possess cleansing power because they contain two types of chemical structures, one soluble in water (hydrophylic) and the other water-repellent (hydrophobic). Ordinary soap, for example, is the sodium salt of a long-chain fatty acid, R-COONa, which, when it dissolves in water, yields an anion, $R\text{-}COO^-$, and a cation, Na^+. The nonpolar, long carbon chain (R) of the anion is similar in composition to fats, oils, waxes, and greases, in which it therefore tends to dissolve; on the other hand, it is water-repellent. The polar $-COO^-$ group, however, is more mineral than organic in nature and is hydrophylic. Thus, when a soapy solution comes in contact, say, with a greasy surface, the long carbon chains of the soap molecules have a tendency to dissolve in the greasy material, in preference to water, while the car-

boxylic heads remain dissolved in the aqueous phase; scrubbing then carries away the grease with the water.

In regard to "dirt," it has been found that soils may for all practical purposes be considered solid particles coated with a film of oil. Because of this oil film, it is necessary for the detergent solution to "wet" the soil if it is to be removed, and to penetrate to the surface to which the soil is sticking. Dispersion via mechanical action and prevention of reprecipitation are then required, as previously mentioned. "Soil is almost always found to be moderately acid,"[39] so alkaline salts as "soap builders" have been found quite useful, although of less importance in the case of synthetic detergents, many of which are active in acid and alkaline solutions.

Commercial varieties of soap are good detergents in "soft" waters. In "hard" waters, however, the calcium and magnesium ions which are present cause the formation of insoluble soaps of these metals, hence no cleaning can occur until enough soap or "water softener" is used to neutralize all of the hardness, after which the excess soap performs its assigned function. Incidentally, no precipitation of the insoluble soaps occurs during washing operations in which enough soap is used, because the excess soap emulsifiies them; however, when fabrics, dishes, bathtubs, etc., are rinsed, the "fresh hard water reacts with the soap residue, forms an insoluble precipitate, and prevents clear rinsing."[32] Soft water rinsing would obviate this, but is seldom practical; the use of sodium hexametaphosphate ("Calgon") also eliminates these deposits, but this compound "reverts to a noncomplex-forming type with time, so that it is not feasible to add this compound to each box of soap flakes or powder sold to correct water hardness."[32]

Search for Synthetic Detergents

It can thus be seen that the $-COO^-$ anion, because of its proclivity to form insoluble precipitates in hard water, is not ideally suited to such use, and it was this realization which inspired the search for synthetic detergents. According to a recent article,[39] "the polar groups most frequently used in surface-active agents to produce water solubility include sulfate, $-OSO_3Na$; sulfonate, $-SO_3Na$; amine, $-NH_2$; amide, $-CONH_2$; other substituted nitrogen groups; and oxygen-containing groups such as ester, -COOR; hydroxy, -OH; and ether, ROR. The presence of unsaturated bonds in a hydrocarbon radical also promotes water solubility. Acid groups such as sulfate and sulfonate are usually neutralized, mostly with caustic soda; basic groups such as amine and substituted ammonium are also neutralized, mostly with hydrochloric acid, thus giving organic salts in both cases." It should be noted that some of the above are cationic agents; i. e., they have relatively inactive anions combined with surface-active cations; these will be discussed later.

A longer hydrocarbon chain is needed in a good detergent than in a wetting agent. "Branched-chain hydrocarbon groups give marked wetting power; the more closely packed straight-chain hydrocarbons give good detergency. Placing the water-solubilizing or polar groups in the middle of a branched chain increases wetting power; placing the polar group at the end of a long straight-chain hydrocarbon group increases the group of properties which make for detergency."[39] There are many other factors involved in detergent action and its relation to detergent structure, but discussion here is unwarranted.

THE petroleum refining industry, in the past decade, has advanced from the role of a supplier of fuels to that of a producer of a wide range of industrial and consumer products. While gasoline, fuel oils, and lubricants are still by all odds the chief products of the industry, a considerable part of the profitable income of numerous refiners is now derived from the sale of special distillates to chemical producers, the manufacture of chemical intermediates (such as butadiene), and the production of "finished" specialties.

During this transition period, even those companies not actively involved have paid increasing attention to these special products, and few are the refiners who are not reasonably well-informed on the production from petroleum of such substances as synthetic rubbers, plastics, and organic solvents. Only within the past few years, however, have many refiners given much attention to the production from petroleum of synthetic organic detergents, although the American chemical industry has long since pioneered the way in this field.

This seeming inattention is quite understandable. To begin with, the sale of "new" detergents, in the early days, was fraught with difficulties for producers who did not possess connections with retail outlets or who could not profitably sell in bulk to those "soapers" who did. Secondly, the price of raw materials for soap—oils and fats—was low, prior to the war, and it took pioneering spirit, ready to accept present losses, to produce "soap substitutes" even from such inexpensive materials as petroleum distillates, especially since these synthetics were relatively unknown to their prospective users. Finally, managements looked askance at a field in which so many different products were produced in so short a time that it was next to impossible to judge their comparative merits and costs, hence their long-term potentialities.

Much of this confusion still exists, since the literature reveals that even the soap and chemical companies are by no means in agreement on the future role of the synthetic detergents and the relative merits of those presently available, but enough petroleum refiners are now in the field to indicate that future prospects are highly interesting and to suggest the need for a general review of the field, with special emphasis on those detergents producible from petroleum fractions.

It is now timely to consider some of the specific detergents which are of particular interest to the petroleum industry, and to note present brands and their manufacturers.

Chief among the present petroleum detergents are the alkyl aryl sulfonates; "production is probably about 50 percent of the total volume of surface-active agents," and "price is lowest of all groups, falling in the vicinity of 40 cents per pound of 100 percent active material";[33] Tariff Commission reports,[25] incidentally, indicate much lower unit prices than this. Alkyl aryl sulfonate detergents are typified by the formula $RASO_3M$, where R is an alkyl (hydrocarbon) group often derived from a chlorinated kerosine cut, hence sometimes termed a "keryl" group; A is an aryl group, usually the benzene group; and M is a metallic ion, usually (but not always) sodium.

"For maximum effectiveness as a detergent, the total chain length of a straight-chain hydrocarbon should be about C_{14} to C_{16}. When the benzene group is introduced, it has been found to be approximately equivalent to a C_4 straight chain,"[39] hence the desirability of a keryl group of about C_{10} to C_{12}; another source[33] mentions the range from C_{12} to C_{18} for "the best detergents." When naphthalene is used as the aromatic group, a smaller hydrocarbon group must be employed. "A larger ring structure, such as naphthalene, or a plurality of short alkyl chains tend to reduce detergency and increase emulsifying power."[33]

Alkyl aryl sulfonates are frequently prepared by monochlorination (insofar as possible) of a kerosine or similar close-cut petroleum fraction, the chlori-

While suds are no final measure, in themselves, of true detergency, it is important from a sales viewpoint to note that most of the petroleum-based detergents have good sudsing quality. Shown is Standard of California laboratory test of an alkyl aryl sulfonate detergent made from petroleum.

nated hydrocarbon then being used in Friedel-Crafts alkylation of the chosen aromatic compound. The ensuing sulfonation attaches a sulfo group predominantly in the *para* position on the benzene ring; monosulfonation is desired. Following sulfonation, sodium hydroxide is usually employed to neutralize the sulfo group; however, ammonia or certain petroleum-chemical amines are sometimes used.[46] Any excess sulfuric acid left from sulfonation is neutralized at the same time, and the resulting sodium sulfate becomes part of the "builder" usually employed in the commercial detergent; "manufacturers find it convenient to get a product of 60 percent active agent and 40 percent sodium sulfate in this way, which is then usually further built to 40 percent active agent, or even a little less."[39] This "builder" is by no means a mere filler or extender, and actually adds to, or detracts little from, surface activity.

First producer of these compounds in this country was the National Aniline Division of the Allied Chemical and Dye Corporation.[2, 26, 27] Many of the basic patents are controlled by this company, whose "capacity at the end of the war has been estimated at 200 million pounds per year,"[33] a figure presumably referring to total output of a 40 percent active material. In the household field, the Nacconols (as these detergents are called) are marketed under the trade-name Swerl through H. J. Heinz Co.

Another large producer is the Monsanto Chemical Company, whose chief products in this field are the Santomerse detergents. No figures are available on Monsanto's capacity; this company is also reported[7] to produce a sudsless detergent, Sterox, "derived from a petroleum chemical and an organic chemical," so it is impossible to tell from the literature whether a 1946 newspaper account of a $3-million "soapless soap" plant expansion at Monsanto, Ill., scheduled for operation in 1947, is concerned with the production of alkyl aryl sulfonates. The same newspaper story stated that "a Nitro, W. Va., plant is also being enlarged for the same purpose."

Sharples Chemical Company[19] is very active in this field, but is said[33] to produce only unsulfonated products, licensing buyers to carry out the relatively simple sulfonation under U. S. Patent 1,992,160, which it has owned since 1935. Three alkylated aryl hydrocarbons are offered for sale: Neolene 210 (monononylnaphthalene), Neolene 220 (dinonylnaphthalene), and Neolene 212 (a blend of the two. These Neolenes, incidentally, are manufactured by Sharples-Continental Corporation. Sharples also produces amylnaphthalene which, while intermediates for surface-active agents, are apparently of chief interest for the synthesis of wetting agents.

Two of Largest Manufacturers

Oronite Chemical Company, subsidiary of Standard Oil Company of California, has recently become most active in this field. Published production figures are confusing, because of the seemingly interchangeable use of 100 percent active and 40 percent active bases, but it would seem that the company's 1947 capacity (100 percent basis) was in excess of 36-million pounds,[13] a figure which checks with a 100-million pound rate (presumably 40 percent active material) reported later in the year.[17] This same report[17] mentioned that "Oronite is said to be trebling its current production," and this is confirmed by a recent speech[36] by George L. Parkhurst, who looks forward to the near-future production of well over 250-million pounds of detergents per year and to the eventual annual production of 300 to 500 million pounds per year; whether these are on a 40 percent active or 100 percent active basis is not clear, although the former seems more likely. In May, 1947, Oronite was said to be "the largest single producer of synthetic detergent basic materials in this country,"[13] although National Aniline presumably debates this point by claiming to be "the largest manufacturer of industrial organic detergents of the alkyl aryl sodium sulfonate type."

Interestingly enough, one source[17] states that "Oronite will sell to anyone, but the chief customer is Colgate-Palmolive-Peet which uses D-40 in its 'soapless soap,' Vel." This might indicate a change in the composition of the latter product, which is supposedly "the ammonium salt of a sulfated monoglyceride."[33] Colgate-Palmolive-Peet is said to be engaged in initial consumer testing of "a novel *cake-form* synthetic detergent"[16] of the latter composition, also using the name Vel.

According to Arthur B. Hersberger,[29] The Atlantic Refining Company's Ultrawet alkyl aryl sulfonates[22] were the first wetting agents of this type produced by a petroleum company, having been on the market since 1936. Three types are produced—liquid, flakes, and beads. A recently completed expansion in capacity gives this company an output of approximately 100-million pounds per year of liquid detergent; "on a 100 percent active basis, the figure will be approximately 40-million pounds." Present plans call for the

marketing of the Ultrawets in bulk, directly to consumers and manufacturers of finished products. One derivative, marketed under the name Ultrawash, is sold directly to retail customers at service stations in Atlantic's marketing territory.

A recent news item[16] states that Standard Oil Company (Indiana) "hopes to have a full-scale alkyl aryl sulfonate) unit in operation at its Wood River refinery early in 1949," its process now having been tested in a pilot plant. "Marketing plans are still in the formative stage, and, at present the company is not planning to produce a spray-dried material."

Numerous other producers are active in this field, including Du Pont, Wyandotte Chemicals Corporation (Kreelons), Nopco Chemical Company (Nopco 1067), Commonwealth Color & Chemical Company (Unitex), Eavenson Chemical Company (Sandev-Detergex), Alrose Chemical Company (Rinsynol 50L and Sorbit AC), Jacques Wolf & Company (Oranap), Arkansas Company (Lanitol F-S), and Publicker Industries, Inc. (HHS).

Alkyl Aryl Sulfonates

Space does not permit a detailed description of the properties of the alkyl aryl sulfonates, especially since these have been adequately discussed elsewhere.[2, 22, 26, 27] Some of the products are rightly described as "general purpose surface-active agents," and quite a number are definitely not detergents. Those which are detergents, however, account for the bulk of production and are now widely employed in the laundry, dry cleaning, textile, leather, and paper industries, and in such special applications as fruit washing and nickel plating. As mentioned, they are usually compounded with alkaline salts. Until recently, they were not effective for washing cottons, primarily because their action here was slow because of redeposition of the soil: the use of such builders as carboxymethylcellulose, however, seems to have overcome this defect.

Many of the alkyl aryl sulfonates are said to have a characteristic kerosine odor, although advertisers of better-grade products use such phrases as "no kerosine or sludge odor." In regard to this property, it is said[33] that "the sodium salts are better in this respect than the potassium salts, and the latter are better than the triethanolamine derivatives." Detergents of this type give an adequate foam at normal temperatures; are resistant "to bleaching and oxidizing agents, and to boiling 10 percent acid or 15 percent alkali";[33] and are effective in water as hard as 300 ppm..

Many of the companies active in this field (and most of the petroleum companies involved) sell the raw detergent to others for blending or resale. There is every reason to believe that the output of this low-cost detergent will continue to increase rapidly.

Surface-active agents in this class[6] apparently include some of the petroleum sulfonates produced either by deliberate sulfonation of petroleum fractions or by extraction from by-products from refining operations involving sulfuric acid treatment. However, these petroleum sulfonates are not usually employed as general-purpose detergents.[30] Manufacturers listed in a Tariff Commission report for 1945 included Humble Oil & Refining Company, Shell Oil Company, and The Texas Company, and it seems probable that some of the "cyclic" petroleum sulfonates produced in that year by such companies as Sinclair Refining Company, L. Sonneborn & Sons, Standard Oil Company (Indiana), Standard Oil Company (New Jersey), and Sun Oil Company should also be classified with these in a general sense. In addition, Solvay Process Company is producing Nytron,[5] "a complex alkyl (petroleum) sulfonate" detergent which may belong in this same category.

Of considerably more importance, however, are the sodium alkyl sulfonates produced from petroleum or similar hydrocarbons (such as a 446-624° F. Synthine fraction) by reaction with sulfur dioxide and chlorine under ultra-violet irradiation, then neutralization of the alkyl sulfonyl chloride (called Mersol in Germany) with sodium hydroxide; the German detergents so produced were known as Mersolates. In this country, Du Pont was for some time the only producer (Merpols, MP's, and Avitone A), but Armour & Company has entered the field with its "411," and others are likely to follow. It is said[39] that Du Pont is building a new plant to double its production.

These products have been previously described in this journal[48] and elsewhere.[28] It is impossible to estimate how large a part of the production of 11,078,000 pounds of acyclic petroleum sulfonates reported by the Tariff Commission for 1945 (at a unit sales value of 14 cents per pound) were sulfonates of the Mersolate type, but a recent article[38] states that "production is estimated as 10 percent of the total production of all surface-active compounds."

In quality, the alkyl sulfonates are quite good detergents. One source[39] states that they are "not quite as high in detergent value" as the alkyl aryl sulfonates, but in any case they are generally similar in properties and belong in the category of inexpensive detergents particularly suited for use in hard water areas. Increased production is anticipated.

Alkyl Sulfates

The alkyl sulfates, or "alcohol sulfates" as some prefer to call them, were the first synthetic detergents to be produced commercially on a large scale in this country; Du Pont, Proctor & Gamble and Onyx Oil & Chemical Company are large-scale domestic manufacturers in this field.

In the past, these detergents have not been produced from petroleum, the long-chain alcohols employed being synthesized by catalytic hydrogenation of the fatty acids of natural oils. Costs have been high, because of the processing involved (even though the raw material is the same as for soap), "in the range of 75-90 cents per pound of 100 percent active material."[38] Production probably accounts for about 20 percent of the total output of synthetic detergents. Trade names in this field include some of the Duponols, Gardinols (recently discontinued), Merpol, Maprofix, Orvus WA, Avitex C, and Dreft.

These detergents, extended with alkaline builders as are the alkyl aryl sulfonates, are "excellent hard-water detergents, even better than the alkyl aryl sulfonates . . . They lather copiously, even in cold water and in hard water";[39] for example, Drene shampoo contains one of these detergents.

Incidentally, a news account in 1944[4] revealed that Shell was producing an alkyl sulfate (Teepol) in England by sulfating C_{10}-C_{11} petroleum olefins, then neutralizing the product. Presumably, however, the sulfate group does not occur uniformly at the end

of the hydrocarbon chains, and it is probable that these surface-active agents ought not to be classed as general-purpose detergents.

In addition to the preceding detergents, which are chemically rather simple in structure, there are several hundred other surface-active agents on the market, many of which are synthesized wholly or in part from petroleum derivatives; these were breifly described in 1943 by R. L. Wakeman and the writer[46] and are further identifiable in recent articles and lists.[33, 39, 43] Since many of these are inherently expensive, because of complex or numerous synthesis steps, and few are real detergents in the full sense, only brief mention will be made of them here. Some of these surface-active agents possess outstanding properties, however, and this heterogeneous group as a whole is certain to see considerable growth in production, since uses are based on specific, superior properties and on the fact that soap cannot be applied at all in many of their uses.

The Tergitol wetting agents, for example, are sodium alkyl sulfates of complex, higher alcohols obtained by devious paths from cracked petroleum gases; the sodium sulfate radical occurs in the middle of the chain, which is extensively branched. In addition to these agents, Carbide and Carbon Chemicals Corporation[9] also produces from petroleum the ethanolamines, which are sometimes used instead of sodium hydroxide to saponify oils and fats and certain detergent intermediates; two cationic detergents, Amine 220 and Amine ES, are apparently produced by Carbide in this manner, using fatty acids from natural oils. Similarly useful amines may be produced from the nitroparaffins, obtainable through nitration of propane and butane.

Certain interesting surface-active agents are based on maleic or fumaric acids, obtainable from benzene (now a growing petroleum chemical) or from a hexane cut. Chemically, these are the sodium dialkyl monosulfosuccinates and alkyl sulfoacetates, typified by Aerosol OT and Nacconol LAL.

Some of the cationic surface-active agents producible from petroleum possess good detergent properties; some German work in this field was recently reported in this journal.[38] In general, however, "their high cost prevents general use as detergents except when their characteristic properties are of special significance."[39] They possess excellent germicidal properties, which have earned them many uses despite their cost ($1.50 to $2.25 per pound on a 100 percent basis). The quaternary amonium compounds are the most important in this class, none of which can be mixed with soap or other anionic agents because the active anions and cations would react to give useless, insoluble precipitates.

Certain nonionic compounds are of particular interest as detergents because they can be used alone or in admixture with anionic or cationic detergents, such as the alkyl aryl sulfonates. Among those derived at least in part from petroleum chemicals are the Spans, Tweens, and Triton NE, some of which are esters of "alkalene oxide" condensation products; e. g., polyethylene glycols. Another interesting nonionic detergent is Monsanto's Santomerse DT, dodecyldiethylenetriamine ($C_{12}H_{25}NH-C_2H_4NH-C_2H_4NH_2$). This last substance is a good detergent even though it does not lather, "a defect in the eyes of most people who are accustomed to associating detergency and lathering power."[39] It may be noted that Sharples Chemicals, Inc., is said[16] to have "a new liquid, nonionic detergent in the pilot plant stage at its Wyandotte, Mich., works"; this might be a petroleum derivative.

No exact information is available on the composition of Ethyl Cleaner, formerly produced by the Ethyl Corp. "from petroleum," but this cleaner has recently been discontinued,[18] hence is no longer a market factor.

It might be mentioned here that soap itself; i. e., the sodium salt of long-chain fatty acids, is capable of synthesis from petroleum or Synthine hydrocarbons, and was so produced in large quantities in Germany during the recent war. As noted earlier in this article, fatty acids may be prepared by the catalytic oxidation of paraffin hydrocarbons, and these acids may then be saponified with sodium hydroxide to yield soaps. Some mention of this subject was made in a recent article in this periodical.[48] The time may not be near when petroleum- or Synthine-derived fatty acids will be used in large quantities in this country, but it is certainly not impossible that this might eventuate.

Economic Considerations

Only in recent years have synthetic detergents and soap been mentioned in the same breath, for soap production has been and still is of a different order of magnitude. Moreover, despite the confusion engendered by the number and complexity of products, it has been clearly recognized that only part of the production of synthetic surface-active agents has been and can be used as detergents.

Soap production, in the early years of this decade, approximated 3500-million pounds annually with distribution of types and raw materials dependent upon marketing and manufacturing trends and upon the wartime shortages and higher prices of fats and oils. Per capita annual consumption, prior to the war, was increasing steadily, falling in the range of 25-29 pounds per person during the years covered in Table 1.

This table shows at least a few trends which are of interest to producers of synthetic detergents; chief of these is the evident growing popularity of "sprayed soap products"—granulated, sprayed powders, etc., along with increased production of "chips and flakes." Almost all synthetic detergents can readily be produced in these forms, although formation into 100 percent detergent (or detergent-builder) cakes is not yet so easy.

As has been mentioned, many of the synthetic detergents are marketed in admixture with considerable quantities of builders, and it is interesting to note

TABLE 1

Soap Production Statistics
(Millions of Pounds)

TYPES	1937*	1939*	1942†
Toilet Soaps	361	405	560
Shaving Soaps	14	13	20
Hand Soaps, Pastes, Powders, etc.	22	24	25
Sprayed Soap Products (Granulated, Sprayed Powders, etc.)	743	895	1,140
Laundry Bar Soaps:			
White	489	661	560
Yellow	633	580	500
Chips and Flakes	390	419	490
Washing Powders, Cleansers, etc.	411	434	270
Soft Potash, Liquid Soaps, Shampoos, etc.	55	70	120
Textile Soaps and Specialties	61	64	90
Miscellaneous	5	5	25
Total	3,184	3,570	3,800

*Based on Bureau of Census statistics, somewhat rearranged.
† Estimates from Soap and Sanitary Chemicals **19**. No. 4, 28-9 (1943).

The final step in the manufacture of most of the synthetic detergents is processing through a "flaker" in which the detergent is dried and thin scales cut off, ready for packaging. —Photo courtesy of du Pont

that soap does not contain such materials to an equivalent extent. The estimate of 3800-million pounds of soap given in Table 1 for 1942 was based on the saponification of 2100-million pounds of oils, fats, rosin, etc., the remaining weight being accounted for by "natural increase on saponification," an average moisture content of 20 percent (i. e., accountable for 760-million pounds), and added builders and fillers.

Comparable statistics are not available for the synthetic detergents, although Tariff Commission statistics[25] have been improving from year to year in completeness of coverage and detail. Total United States production of synthetic surface-active agents, according to this source has been as follows: 1943, 114,360,000 pounds; 1944, 152,636,000 pounds; 1945, 184,442,000 pounds; and 1946, 239,197,000 pounds, all on a 100 percent active basis. Recent Tariff Commission reports[25] offer the most complete breakdown available of detergent production, sales, and manufacturers, but only a few additional statistics are vital here.

To begin with, "sulfonated paraffinic petroleum compounds and salts" were not reported separately until 1943, when reported production totaled 14,327,000 pounds and sales were valued at 9 cents per pound. In 1944, "petroleum sulfonate" production was reported at 29,519,000 pounds, with sales still at 9 cents, while in 1945 this class was further broken down into cyclic petroleum sulfonates (23,703,000 pounds produced, with sales at 13 cents per pound) and acyclic petroleum sulfonates (11,078,000 pounds produced, with sales at 14 cents per pound). Preliminary 1946 figures show that 36,598,000 pounds of cyclic petroleum sulfonates were produced, with sales at 8 cents per pound, while production and sales figures for acyclic petroleum sulfonates were grouped with other agents and are not distinguishable.

These figures for petroleum sulfonates do not include the alkyl aryl sulfonates; in 1943, such production totaled 29,959,000 pounds, with sales at 19 cents per pound, and in 1946 these figures were 52,599,000 pounds and 19 cents, respectively.

Production and price figures are given for many surface-active agents made in part from petroleum, and a few are of interest for comparison with the alkyl aryl and petroleum sulfonates. Cationic agents (quarternary ammonium compounds) sold for $1.19 per pound in 1946; "nitrogen-containing" surface-active agents for 52 cents per pound; and "polyhydric alcohol esters and ethers" (production, 10,148,000 pounds) for 47 cents per pound. "Sulfated and sulfonated fatty acids" for 19-23 cents per pound and sulfonated and sulfated oils, fats, and waxes for 18 cents per pound (production, 38,337,000 pounds) are typical of the less expensive nonpetroleum agents.

It should again be emphasized that a large part of the above production went into nondetergent uses, in the strict sense of the term. In the words of the 1945 Tariff Commission report, these products "are active in a variety of mixtures in which soaps would be quite ineffective." Use in hard-water areas as wetting, penetrating, foaming, dispersing, or emulsifying agents is typical. Surface-active agents are important in the textile industry for degumming, desizing, scouring, and use in dyeing, bleaching, mercerizing, etc.; may be used to clean metals prior to plating; are valuable ingredients of such widely different items as electroplating baths and dentifrices and shampoos; and have countless applications based on their rather-generally-possessed ability to be used in mildly acid solutions, where soap cannot be employed because it decomposes, forming insoluble fatty acids.

The economic importance of the synthetic detergents (and other synthetic surface-active agents, for their specific uses) for use in hard-water areas may be judged by the estimate that the average family's soap bill would be $1.65 per year if absolutely soft water was used; $8.89 per year with water of 10-grain hardness; and $28.42 with water of 35-grain hardness. While few areas have water as hard as the latter extreme, and many cities soften their water to 3-5 grains per gallon, some cities use hard water of 15-30

—Photo courtesy of Drefi

Two glasses, both washed in hard water, rinsed and left to dry without polishing. Left, with soap and right, with one of the synthetic detergents. The economic value of the use of synthetic detergents in hard-water areas is no longer questioned. They can also compete even in soft-water regions.

grains per gallon, and "an average figure more or less representative of the hard water of the country would be 10 grains per gallon. . . . It is therefore desirable for general household cleaners to be effective in water of at least this degree of hardness."[32]

There is wide disagreement within the soap industry as to the ultimate future of the synthetic detergents.[10] While almost all "soapers" are producing or marketing some detergents and state that they are engaged in evaluating others, there seems to be a definite feeling on the part of some that "we've been dragged into this, but it's certainly too bad we couldn't have been left alone to market 'good old soap.'" On the other hand, a number of major soap companies have been among the leaders in developing and energetically marketing synthetic detergents, and it seems probable that the whole industry will have to follow the path of these leaders, willy-nilly. Some of the most reluctant, a few years ago, are now running abreast of the pioneers, at least in their advertising efforts.

Within the chemical industry, and that branch of the petroleum refining industry actively involved, there seems to be confidence that the synthetic detergents will assume a role of snow-balling importance, although public utterances are usually carefully phrased to avoid offending soap interests. Few chemical and petroleum companies appear ready to embark on full-fledged retail sales campaigns, however, since many seem to prefer to sell their intermediates or finished detergents to soap companies for actual marketing.

Two papers presented in succeeding years (1947 and 1948) to annual meetings of the Association of American Soap & Glycerine Producers are indicative of the trend of developments, which are proceeding at a rapid pace. In his 1947 paper,[36] George L. Parkhurst, president of Oronite Chemical Company, stated that several questions had to be answered before it could be foretold whether synthetic detergents would compete successfully with soap in soft-water as well as hard-water areas: 1) quality and price considerations—believed to be satisfactory; 2) ability to wash heavily soiled cottons—not yet comparable for the low-cost detergents, but potentially so; 3) capability of being made into bars—not yet satisfactory, and 4) shortages of chemical ray materials (benzene, naphthalene, chlorine, caustic soda, and builders) — capable of eventual solution. Parkhurst made the definite statement that "it is my belief that in terms of quantity and in terms of costs the synthetic detergents made from petroleum will definitely have the edge (over those made from fats and oils)—so far as the general market is concerned — and probably the edge in other markets as well, except for certain limited markets where specialized types of synthetics have recognized advantages."

In the year that has followed the presentation of this paper, definite progress has been made in solving the problems posed by Parkhurst. As Kenneth T. King, manager of Du Pont's Fine Chemicals Division, told the 1948 meeting of the soap producers, [21,31,43] the problem of washing heavily-soiled cotton with detergents has been solved by the addition to these materials of such builders as phosphates, carbonates, borax, etc., but more specifically by the addition of carboxymethylcellulose. In the past "most of the synthetic detergents would remove the soil but were not efficient or satisfactory in preventing soil redeposition." Carboxymethylcellulose reduces or prevents such deposition, "is compatible with most synthetic detergents and other chemical builders," and only small percentages need be employed. This chemical is currently produced by Hercules Powder Company, Du Pont, the Wyandotte Chemicals Corporation, Phillips Petroleum Comany, and Dow Chemical Company.

In regard to forming detergents into satisfactory bars, Colgate-Palmolive-Peet seems to have solved the problem satisfactorily in its new 25-cent bar of Vel toilet soap.[20] In addition, a recent news item[23] states that Atlas Powder Company has a new "cake-form synthetic detergent . . . based on G-1226 (a fatty acid polyoxyethylene derivative) and an organic filler" and that Atlas may license its cake-forming process to its customers. It seems not at all unlikely that this problem will eventually be solved for most of the important detergents.

Statistics of the present-day industry are highly confused, both by the fact that not all sources report on a 100 percent active basis and by the general lumping together of all surface-active agents instead of just detergents. As J. W. McCutcheon points out,[33] Tariff Commission figures indicate a 1946 output of 200,860,000 pounds of detergents, exclusive of (non-detergent) sulfated and sulfonated oils; this total output, on a 33 percent active basis, would correspond to sales of 600 million pounds. Kenneth T. King[31]

estimates 1948 production capacity at 700 million pounds (on this latter basis), "the largest production starting with petroleum as a raw material." Arthur B. Hersberger[29] emphasizes that such figures "include a lot of material whose activity is on the order of 40 percent," and states that "it is my own belief that if all figures were reduced to a 100 percent active basis, production would be more like 350 million pounds."

Regardless of other contentions, analysts of synthetic detergent economics seem to have agreed that output of these materials (probably including other surface-active agents) will reach one billion pounds per year (presumably on a 33-40 percent basis) within the next few years, as rapidly as plants can be built and chemical materials obtained. All point to increased activity in the production of new soaps containing valuable builders, including quantities of synthetic detergents, and few care to predict that the output of these synthetic detergents will cut into soap production of 3 to 4 billion pounds per year, preferring to hope, audibly, that the trend toward growing demands for cleansers will absorb total production of both. Incidentally, soap production in recent years has been much lower than the above figures, because of shortages.[42]

Prices—Soap vs. Synthetic Detergents

As regards soap, raw material prices are now such that the petroleum-based synthetic detergents are definitely cheaper,[24] but economists rightly point out that the historic price of many fats and oils is much lower than the levels caused by wartime and postwar shortages and that, when abnormal demands are eliminated, natural oils and fats will be much cheaper. Moreover, they point out that "there will always be a big soap industry because its raw material is by-product fat," hence that "the influence of the synthetic detergents industry can only tend to lighten the demand for fats and result in lower fat prices. Soap may again be as cheap as synthetics."[31]

Costs and general utility in a normal market, plus the intangible factors of demand based on advertised "sizzle"—"speedy dishwashing, freedom from tattletale gray, mountains of suds," and so forth,[15] will eventually enter into the balance between soap and synthetic detergent production. In the meanwhile, Swerl, Glim, All, Vel, Breeze, Dreft, and Tide, the packaged household detergents sold by Heinz; General Aniline; Detergents, Inc.; Colgate; Lever Brothers; and Proctor and Gamble; respectively, are meeting competition from other producers eager for their share of the field—Klens, Rad, Scoop, Sheer, Tops, Woolfoam, Betty Brown Bo Peep, A2Z All Purpose Soapless Suds, Savogran Coldfoam, and Atomic Fluff.[11]

In the midst of all this confusion, it still seems relatively clear that the low-cost, petroleum-based synthetic detergents will find a market whose ceiling is not really determinable at present. Soapmakers may not have to abandon their soap kettles, but only the future will tell if they will ever again be able to operate them at capacity. Meanwhile, those petroleum companies already in the field are expanding their operations with quite reasonable assurance of markets for their products, and additional entries into this field seem certain. Few are the petroleum chemicals with potential billion-pound markets, so present activity in this field is completely understandable.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the several companies which supplied information material, which have been included in the bibliography. Thanks are also in order to Mr. Kenneth T. King and Dr. R. M. Simington of E. I. du Pont de Nemours & Co.; Mr. John C. Lane of the Institute of Gas Technology; and to Dr. Reginald L. Wakeman of Onyx Oil & Chemical Company, for their comments and suggestions.

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The Protection and Maintenance of Petroleum Property

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THIS thorough-going report on the protection and maintenance of petroleum property points out that this practice is dependent largely on proper application and selection of protective coatings. In discussing the principles of good application practices, the author lists four fundamental requirements of protective coating maintenance: 1) surface preparation; 2) proper conditions for coating application; 3) adequate film thickness, and 4) material selection. Suggestions for the selection of materials are discussed in detail.

One of the recommendations is the controlled and coordinated field testing under engineering guidance.

IN THE November 12, 1947, issue of the Journal of Commerce, New York, Joseph E. Pogue, vice president of Chase National Bank, announced that the petroleum industry would spend $13 billion during the next five years to meet the future oil needs of the world. In the same issue, William R. Boyd, Jr., president of American Petroleum Institute, in discussing the situation in the United States, indicates that approximately $4 billion will be spent in this country within the next two years to increase its productive capacity; furthermore, that its present total investment in the country approximates $18 billion. These figures indicate the tremendous wealth in the property of the petroleum industry that must be maintained and protected.

Protecting a Vast Investment

The use of protective coatings is one of the important means of maintaining and protecting this vast investment. Through the advance of modern science, present day petroleum refineries and plants are essentially vast chemical plants involving all the problems of protection against exposure to high concentrations of moisture, acids, alkalis, petroleum solvents and oils. The subject of the protection against these reactive agents is complex and not simple. It merits much greater discussion than can be covered in this brief review, but with the hope of being of some service to the petroleum industry, we will try to highlight some of the important engineering aspects of the problem.

Too often in the use of protective coatings, insufficient thought is given to the surfaces or conditions under which they are applied with resulting frequent disappointments in performance. Since the cost of the coating is 20 percent or less of the total cost of the job, it is apparent that the indifferent and indiscriminate application of protective coatings is, to say the least, very poor economy. There are certain fundamental requirements which must be carefully and properly followed if satisfactory performance is to be obtained; namely,

1) The preparation of surface.
2) Application of coatings under proper conditions.
3) Adequate film thickness.
4) Selection of material.

In the maintenance of petroleum plants, as previously mentioned, we are dealing with equipment that has been exposed to varying concentrations of water, acid fumes, alkali solutions, solvents and oils. These reagents are usually deposited on the surface of the equipment and unless adequately removed before painting will destroy the adhesion and performance of the new coating. Tests with litmus paper will indicate the nature of the surface deposit and can be used advantageously to indicate the thoroughness of its removal. Water and steam may be a means for the removal of these chemical deposits. Oils and greases may be removed with volatile solvents but these must be renewed frequently to avoid simply spreading the contaminant. Careful inspection of areas exposed to water spray is also necessary to insure that there are no deposits of the solids of the water as an interfering film on the surface. We have seen crusts of water solids deposited in areas of this kind, particularly where raw water of high solids has been used for cooling purposes. These crusts must be removed or otherwie they will destroy the adhesion of the succeeding coats of paint.

In most cases, we are dealing with steel structures and equipment which have rusted and this rust must be removed from the corroded areas, and the clean metal should be promptly spot primed. Under some conditions, particularly with steel equipment, it has been advisable to prepare surfaces by sandblasting to remove the old contaminated protective coating and the corrosion from the rusted metal at the same time. In this case, very prompt priming of the sandblasted surface is also necessary. If not cleaned by sandblasting, careful cleaning by other means is necessary; however, the effectiveness of these methods will be in direct proportion to the thoroughness of the operation.

Application of Protective Coatings Under Proper Conditions

In ordinary painting practices, we are warned not to paint during extremes of temperature, either too low or too high; when the surface is wet or the sur-

These "blimps" are located at East Chicago, Indiana. When this photograph was taken the white finish had been on these tanks for 60 months without loss of reflective value.

face is not clean. This advice is sound and is generally applicable. In petroleum refineries, however, conditions vary from ordinary or normal to extreme conditions, requiring special consideration. In most refineries, there are two types of exposure in particular that present difficulties in maintenance painting; these are the chemical isomerization areas and areas adjacent to the water cooling towers. In these areas, in addition to the need for careful surface preparation, certain other precautions are necessary to secure satisfactory performance.

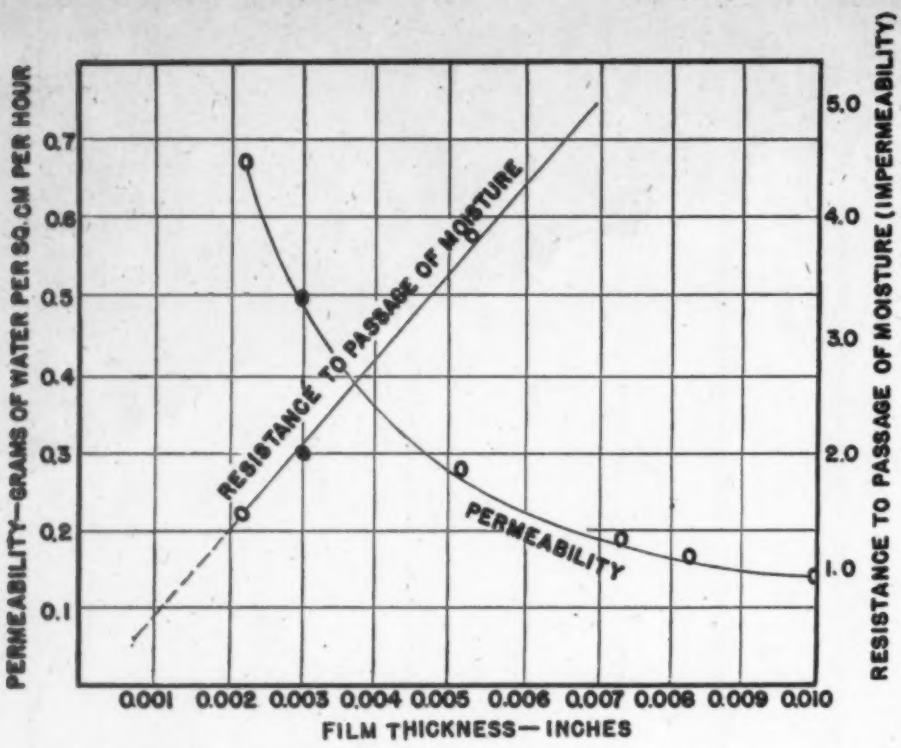
In the chemical isomerization areas and areas adjacent to water cooling towers, after removal of the acidic deposits and chemical salts, application of the protective coating system is necessary with as little delay as possible to reduce the contamination of these surfaces with chemical deposits between the coats. When the recoating of these surfaces is delayed, chemical deposits accumulate on the previous coat, thereby sandwiching an interfering water-sensitive layer that weakens the intercoat adhesion of the system. In view of this, it is suggested that the maintenance painting schedule be organized so as to do all recoating in as short an interval as possible.

Where a complete removal of the old finish is involved, a minimum of three coats is recommended, two coats of primer and one coat of the finish or topcoat. If the application is by spray, and the proper protective coatings are used, recoating under reasonable weather conditions may be carried out at intervals of from four to six hours between coats. It should be possible to apply two coats of primer in one day and the finishing coat the following morning. During the long summer days there is the possibility of using two daylight shifts, making it possible to apply all three coats in one day, which would represent the most desirable conditions in maintenance painting in these areas in order to minimize the chemical deposits between coats. Where application is by brush, longer periods of drying are necessary between coats so as to avoid disturbing the film of the previous coat, but in any event the shortest recoat schedule permissible should be followed to minimize intercoat contamination.

Adequate Film Thickness

Next to having a clean and properly prepared surface, the application of an adequate film thickness of the protective coating system is perhaps the most important consideration. In maintenance painting of surfaces subjected to moisture and to chemical fumes it is important that adequate film thickness of the protective coating system be applied to obtain a proper degree of impermeability to moisture and gases to provide protection.

Measurements made on the passage of moisture through protective coating films of varying thicknesses, as illustrated in the accompanying chart, indicate that a minimum film thickness of 3 mils is necessary to obtain a practical degree of impermeability to moisture and gases. This will help to explain why protective coatings perfectly sound in quality, if used in thin films inadequate for good impermeability, are disappointing due to their early



failure. A minimum of 3 mils and preferably 4 to 5 mils are advisable to obtain good protection over surfaces that have been cleaned to the bare metal and, as previously indicated, by the use of two coats of primer and one coat of finishing material.

While stressing the need for adequate film thickness for satisfactory protection, a word of warning is also pertinent on the danger of applying films that are too heavy. There is less danger of this in brush application than with spray application. Unless care is exercised, extremely heavy films may be applied by maintenance painting crews on large structures. We have seen applications of a single coat by spray on large petroleum storage tanks and on the hulls of ships, that approximated from 7 to 12 mils in thickness, whereas a single coat should not have exceeded 2 to 3 mils. These excessively heavy films, as a result, caused difficulty in surface drying, wrinkling and slow hardening through, requiring unusually long periods of drying before further coats can be applied or before the equipment is ready for service.

Spraying, because of its lower cost of application, is rather frequently used in the maintenance painting of petroleum plants. We have stressed the danger of applying excessively heavy films but in spraying there is also the risk of the application of films that are less than 1 mil in thickness and, therefore, too thin. Because of this, special attention to film thickness should be given on each coat when applied by spray.

Selection of Material

The preceding discussion is applicable to the general problems of maintenance protection of petroleum property. The various conditions of exposure in petroleum plants require careful judgment and experience in the selection of materials to be used. While the performance of protective coatings can, to some degree, be judged from laboratory evaluations, the experience of practical field tests is definitely necessary to significantly judge their performance. While many factors require consideration in the selection of materials, our best judgment of their application for some of the more important and perhaps more difficult requirements for petroleum plants are suggested.

Chemical isomerization areas are the ones most critical in their requirements for protective coatings. We have already discussed the need for quick recoating schedules to avoid intercoat contamination. Since resistance to moisture and acid fumes, among other requirements, is necessary, we believe the phenolic coatings afford the best chance of giving good protection in these areas.

In some operations in chemical isomerization areas exposure to alkaline materials, like caustic soda, etc., are also involved. Under these conditions, the use of chlorinated rubber base protective coatings is recommended.

The chemically resistant coatings based on vinyl resins are also exceptionally inert to moisture, acid and alkali and while these might also be used under the conditions above mentioned, there are certain practical limitations to their use. They are appreciably higher in initial cost, are low in solids, more difficult to apply, less foolproof in adhesion and require the utmost in careful surface preparation. For the most applications, these vinyl coatings require sandblasting of the surface before use. However, since they have greater chemical resistance than other commonly used organic finishes, an evaluation of them under practical operating conditions in these areas is worthy of consideration to determine the economics of their use in comparison with phenolic and chlorinated rubber coatings.

Refined Tank Storage

A large part of the investment of the petroleum industry is in storage tanks for their finished product. Under normal conditions of exposure, orthodox oleoresinous coatings have given fair performance. Alkyd finishes, however, in this service have been far superior in protective value because of greater durability and better appearance retention. Furthermore, the alkyd finishes have made possible the use of tank white finishes, which in addition to adding considerably to the appearance of the storage tank farm, has had outstanding economic value in reducing evaporation losses of petroleum products.

In *National Petroleum News* (February 6, 1946), G. W. McCullough, H. R. Legatski and H. J. Pixley reported the results of a comprehensive study of methods of "Reducing Losses of Volatile Liquids in Atmospheric Pressure Storage." Their results indicated that the evaporation loss of non-painted tanks during the months of May, June and July averaged 1.32 percent per month as compared with 0.53 percent for tanks painted in white. Furthermore, that with water-sprayed white tanks the loss during this period was reduced to 0.22 percent. These tanks contained 12-pound RVP natural gasoline. The temperature data in their report, indicate adequately the reason for the economic advantage of the white finish on these storage tanks.

One of the principal problems of petroleum pro-

Temperature Data on Group of 10 Psig. Working Pressure Spheroids, Showing Effect of White Painting

	WITHOUT WATER SPRAY			WITH WATER SPRAY		
	Max. Vapor Temp. °F.	Max. Liquid Temp. °F.	Avge. Atmos. Temp. °F.	Max. Vapor Temp. °F.	Max. Liquid Temp. °F.	Avge. Atmos. Temp. °F.
No Paint	160	82	79	..	..	..
Painted White	109	82	88	84	82	88
Painted Aluminum	147	89	87	92	86	88

ducers is the protection of lease tanks from interior corrosion. These are principally bolted steel tanks used for temporary storage of crude at the wells. Their life is seriously limited because of the corrosive action of salt water, hydrogen sulfide and other impurities present in crude oil.

Many types of organic coatings that have been tested for this requirement have failed to give promise. While there may be other coatings worthy of further consideration, at least the chemically resistant vinyl finishes and the thermosetting phenolic coatings still hold promise of affording the required protection for the interior of these tanks.

The phenolic and vinyl type coatings just mentioned are the types, however, whose successful use is almost entirely dependent on proper surface preparation and careful application to give uniform continuous films of the proper build. While suppliers of the thermosetting phenolic coatings and the chemically resistant vinyl coatings are in a position to recommend methods of application and the proper use of these coatings, there is some question in the attitude of the petroleum industry as to the desirability of their undertaking the problem of applying these type coatings under the critical conditions required. As a result, a number of applicators for these coatings have been organized to supply this service to the petroleum industry.

The use of these organic interior coatings in the petroleum industry, we believe is still on an experimental basis. The true economics of this procedure can be determined only by the type of field testing that is now in progress and it is strongly recommended that this type of investigation be continued to a conclusion. It is further recommended that the fabricators of tanks and other equipment for this service also investigate and join in the evaluation of the use of these organic coatings. The shop application by the fabricator offers the advantage of more uniform conditions and the opportunity of more readily and thoroughly standardizing the coating procedure than is possible in field application.

Stacks and Finishes for Hot Surfaces

In many petroleum plants that are well maintained, the high stacks, which are the first part of the plants visible from a distance, are poor in appearance and seem neglected. This is due to the fact that the best of the previously available organic coatings have limited life under the high temperature of these surfaces.

The temperature of the hot zones of these stacks ranges from 400 to 600° F. or higher. Under these conditions, previously available organic coatings have blistered or flaked away after short periods of exposure. Among the better available coatings have been those based on metallic zinc pigmentation. Heat-resistant aluminum finishes, very low in binder, have also been used with some degree of satisfaction. These coatings, while better than average organic coatings for hot surfaces have, however, for one reason or another, had a limited service life.

We have long felt that the successful solution to this problem would require a new type of binder. The advent of silicone resins, with their greater heat resistance, offers the possibility that they will be much more satisfactory. The silicone coatings are high in cost but if they give protection and good appearance to the stacks and other hot surfaces, where other finishes fail, they should be economically sound. Silicone aluminum heat resistant finishes are now available and should be thoroughly evaluated by all those concerned about the problem.

Miscellaneous Other Petroleum Property

There are, of course, many problems in the maintenance of petroleum property that space does not permit discussing in detail. For example, for galvanized metal buildings so often used in the industry's plants, the zinc dust galvanized metal primers have an established record of good performance. In the marketing field of the petroleum industry, the alkyd finishes have likewise established their superiority for durability and good appearance retention on service stations and transportation equipment, like trucks, tank cars and marine carriers. The maintenance of these valuable elements of the petroleum industry is receiving the constant and alert attention of the protective coating industry in the effort to provide superior protection and appearance.

Conclusion

The problems in petroleum plant maintenance, which have been discussed indicate the need for an engineering approach in their solution. The principles of surface preparation, application conditions, film thickness and the selection of material are all important to achieve the best possible results. Since laboratory evaluation of coatings for these difficult service conditions is not too significant, it is urged that controlled and coordinated field testing be organized in their evaluation. This is preferably accomplished under the direction of an engineering group, who can best establish the correlation of test results and coordinate the information on performance, as the basis for concluding the soundest solution to the problem.

* * *

Catalysts in Petroleum Refining

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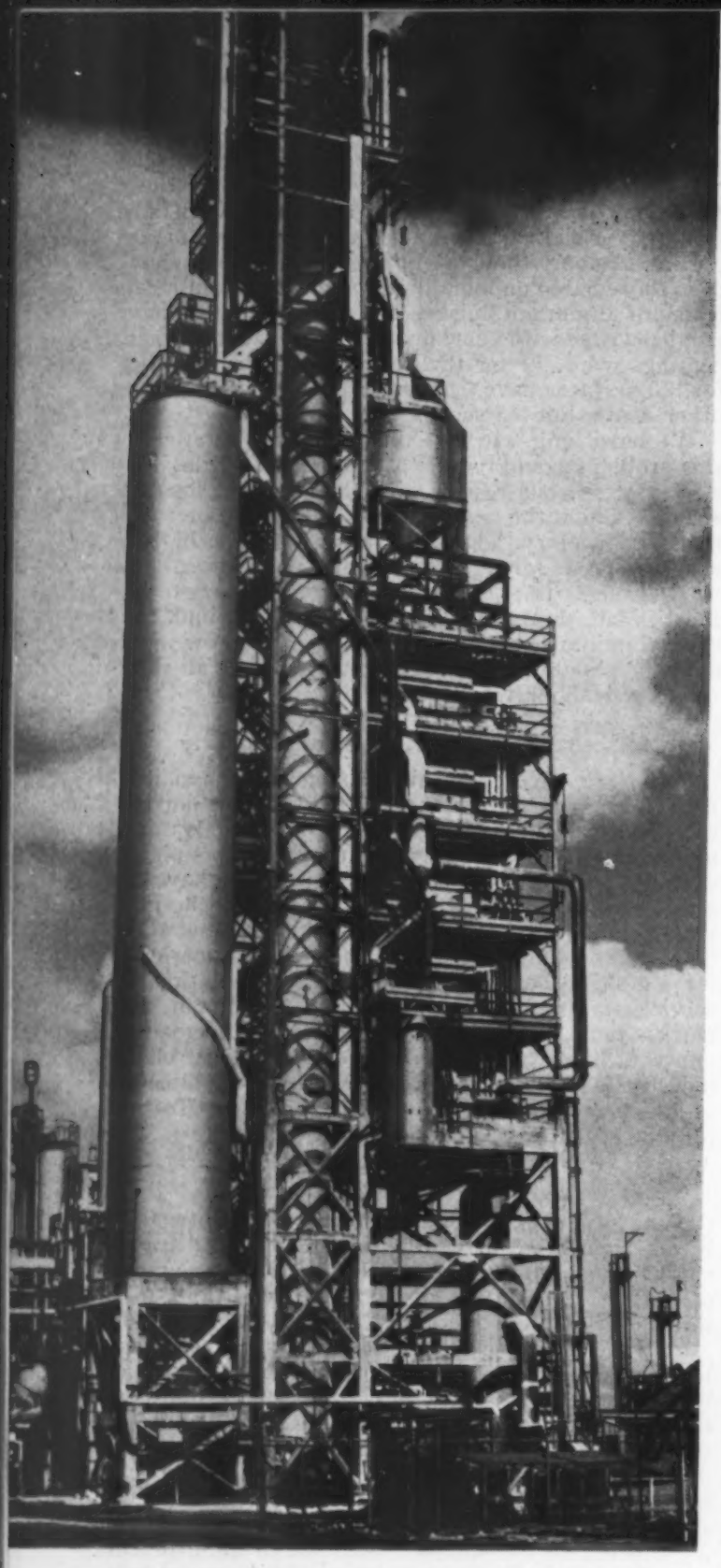


Thermofor catalytic cracking unit at Alma, Mich., which uses solid catalyst of large particle size in a "moving bed" operation.

IT IS not the purpose of this article to give a review of all the numerous catalysts which have been proposed for use in the petroleum industry, a task already undertaken repeatedly, but it is intended to present to those not intimately acquainted with the development of applied catalysis a picture of the present status of catalysts finding use in different branches of the industry.

THE famous Swedish scientist Berzelius in the beginning of the 19th century defined catalysts as substances which cause reactions to proceed between compounds without participating in the reaction at all or to a very limited extent. Later this definition was somewhat broadened to describe a catalyst as a material which apparently does not directly take part in a reaction but has the capacity to initiate it or accelerate it or to direct or steer it along certain definite lines when it could otherwise proceed in several directions (Wilh. Ostwald, O. Mittasch[1]).

According to others, catalysts will not iniate reactions but have an "accelerating effect which, when combined with selectivity, may result in the ability to direct reactions."[2] Whichever of the numerous definitions given in literature may be preferred, the most important point is that the catalyst is not chemically changed, at least not permanently, in or by the reaction it influences. Since reactions are accelerated, enhanced or facilitated by catalysts, it is an important characteristic of catalysts that in cases where chemical substances are able to react also without them, their presence makes it possible to carry out the reaction under substantially milder conditions so that undesired side reactions are prevented and better yields of the desired products are obtained.

On the other hand, since the catalysts remain substantially unchanged during the reaction, a relatively very small amount of them is able to transform or convert large amounts of reactants, requiring only occasional reactivation or regeneration to remove deposits which may form on the catalyst surface and deactivate them. Catalytic reactions occur on the surface of the catalysts and it is therefore a prerequisite for the useful employment of catalysts to enlarge their surface as much as possible and to contact them in the most intimate manner possible with the reactants. The activity of solid catalysts depends in part on the total extent of their surface.

Numerous attempts have been made to explain the action of a catalyst in initiating or accelerating a certain reaction. According to one version the catalyst

intermediately takes part in the reaction, an intermediate combination of one of the reactants with the catalyst substance being formed first which, however, is decomposed again particularly under the influence of a second reactant while the reaction proceeds, so that the catalyst is re-formed.

According to other hypotheses the action of a catalyst is thought to be of a more physical nature. It will, however, be proper to say that the causes of catalytic effect may vary depending on the kind of catalyst employed and on the reaction in question. In a number of cases, at any rate, there cannot be any doubt that the catalyst chemically enters into the reaction and that the intermediate product thus formed is decomposed when the reaction proceeds.

It has been possible to isolate such intermediate products. A well known example of this kind is the formation of ethyl alcohol from ethylene and water using sulfuric acid as the catalyst, where ethyl sulfuric acid is formed as an intermediate addition product which is then decomposed by water to form ethyl alcohol and reform sulfuric acid according to the equations:

$$CH_2=CH_2 + HOSO_2OH \rightarrow CH_3CH_2OSO_2OH$$
$$CH_3CH_2OSO_2OH + H_2O \rightarrow CH_3CH_2OH + HOSO_2OH$$

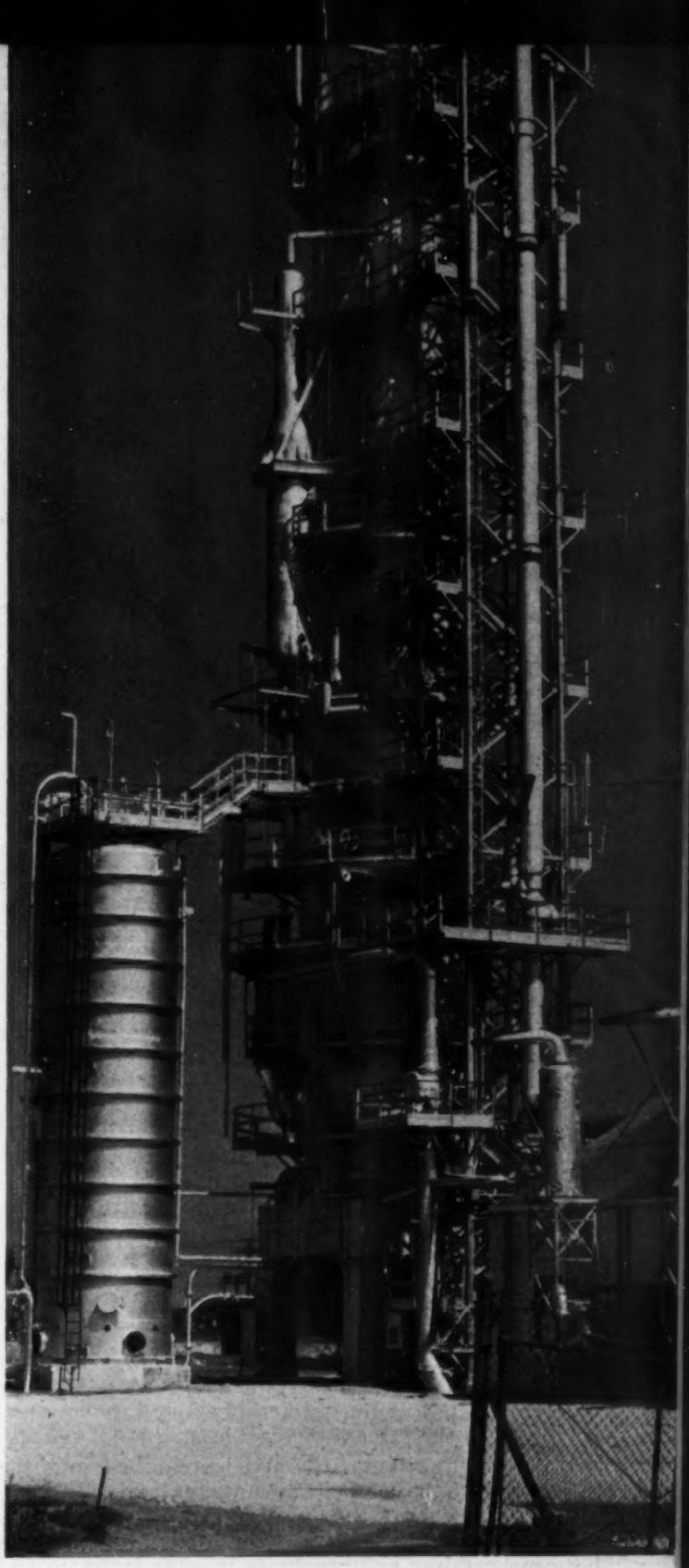
There are good reasons to believe that in the case of most of the catalytic processes employed in petroleum chemistry the effect of the catalyst is of a more physical nature. In the case of the alkylation of an isoparaffin by an olefin the former may, according to the so-called carbonium or carbonium ion theory, be ionized to some degree by the catalyst, the negative carbonium ion of the isoparaffin molecule then combining with the olefin. The larger carbonium ion thus formed then combines with the positive H ion set free in the preceding ionization of the isoparaffin. In the case of the polymerization of olefins Whitmore[3] assumes a positive complex formation resulting from a proton addition to the double bond of the olefin under the influence of the catalyst and the addition of this complex to the double bond of another olefin molecule, a larger complex being thus formed. If the latter looses a proton, a dimer is obtained, while on further polymerization a still larger complex is formed.

Promoters

Not all catalysts are active by themselves or are sufficiently active to accelerate the reaction to the desired and highest possible degree. They, therefore, have to be treated either before or during their use with materials capable of activating or promoting their activity. Such materials are called promoters. The promoters need not be catalysts themselves, though there are promoters which have an independent catalytic action, but when employed in relatively small amounts in connection with the catalysts proper, they co-activate the reaction. The promoters, by increasing the activity of the catalyst, not only increase the rate of the reaction beyond that caused by the catalyst alone but they may also prolong the life span of the catalyst.[2]

Reactions and Types of Catalysts

There are innumerable catalytic reactions in inorganic and in organic chemistry. Most, if not all, of the reactions of living matter are caused or accelerated by natural catalysts, the so-called enzymes. They are generally highly specific, one enzyme working only in one special direction and on only one and the same kind of reactant. Their production and re-production in plant and animal as well as their well controlled action belong to the best kept secrets of nature.



UOP catalytic cracking unit at Detroit which uses powder catalyst in a "fluidized bed" operation.

In man's organic chemistry the most diversified compounds have been found suitable to work as catalysts. Most of those here described are inorganic compounds. They have the advantage that their separation from the reaction products and their regeneration is generally considerably easier than that of organic catalysts. Among the useful inorganic

catalysts are gases, liquids and solids, metals, metal oxides, metal salts, and acids. Though their action is to a certain degree specific, this specificity cannot be compared with that of the enzymes, and it will be seen later that one and the same type of inorganic compound is able to catalyze reactions of a rather different nature, particularly in the field of hydrocarbon chemistry and that, vice versa, catalysts of a very different chemical nature are capable of inducing one and the same kind of chemical reaction.

Promoters, too, can vary widely. In numerous cases physical mixtures of inorganic substances are used as combined catalysts, such as two or more different metal oxides, because they have proved to give better effects than the single components, which sometimes will not show any catalytic effect at all. It appears somewhat arbitrary whether in such a case one wants to designate one of the components as a promoter for the catalyst or as one part of a combined catalyst.

It is often useful to arrange the catalyst proper on a carrier material, primarly to give the catalyst a large effective surface. For this reason such carriers usually are of a highly porous nature. Suitable materials include kieselguhr, fuller's earth, activated alumina, bauxite, and the like. The carrier may be inert itself, but it can also be active or activated, thus forming a part of the catalyst proper.

Manner of Contacting Catalyst and Reactants

Catalysts which are liquid under operating conditions, such as sulfuric acid, can be used in this liquid form, the liquid or gaseous reactants being passed through this liquid catalyst under suitable conditions of temperature and pressure. The liquid catalyst also can be absorbed by a porous inert carrier.

Solid catalysts can be arranged in stationary or fixed beds through which the reactants are passed. In this case different shapes and sizes can be given to the catalyst material, either to increase its effective surface or/and to enhance and facilitate the passing of the reactants therethrough. According to their nature and the purpose in mind, natural catalysts, such as clays, bauxite or bentonite, can be employed as natural granules or fines. Most solid catalysts can, however, also be shaped to form pellets, spheroids or beads.

Solid catalysts can also be arranged in a so-called fluidized state, i.e. as a moving bed. In this instance the catalyst material is generally in the shape of finely divided particles assembled to form a more or less compact column, preferably moving countercurrently to the stream of reactants.

Both arrangements, the fixed solid bed and the fluidized bed, have their advantages and disadvantages. In the case of the fluidized bed, where the catalyst particles are suspended in the reactants, contact between catalyst and reactants is more intimate and complete and the contact surface is substantially larger than with the use of a fixed bed of pellets, or the like. The reaction, therefore, will be more complete in the first case for a single pass of the reactants. On the other hand, losses in catalyst material will occur when the fluidized bed is moved out of the reaction zone to be regenerated and is returned to this zone after regeneration. Catalyst breakdown will occur because of the relatively strong mechanical wear and tear during this movement. In the case of the fixed bed of solids which are regenerated in place losses of this kind are smaller, and the conversion apparatus can often be simpler and more compact. Both types are in practical use.

Inactivation, Poisoning and Regeneration

Certain catalysts are very sensitive to specific impurities contained in the reactants. These catalysts are quickly transformed by such impurities into catalytically inactive chemical combinations. The impurities are termed poisons. In being poisoned a catalyst is subjected to a permanent chemical transformation. Of the catalysts used in the production and conversion of hydrocarbons those metals are particularly susceptible to poisoning which form sulfides when contacted under suitable conditions with certain organic or inorganic sulfur compounds. The metals of the first transition group of group VIII of the periodic system, iron, cobalt, and nickel, are examples of this type. To avoid poisoning, the reactants employed have to be freed as far as possible from dangerous impurities before they are contacted with the catalyst. In order to reactivate a poisoned catalyst of this kind it has to be reconverted into the metal by a reducing process, or the like.

Deactivation of a catalyst during use must be distinguished from poisoning. While the latter, as shown, is caused by impurities of the reactants, deactivation takes place gradually as a regular and unavoilable incident on protracted use of a catalyst in the production, conversion, or refining of hydrocarbons. In the case of the use of anhydrous salts or acids or of saturated solutions and of the formation of water in the desired reaction, inactivity is caused by dilution of the catalyst by the water of reaction. Regeneration of the catalyst in such cases consists of dehydration.

Another important type of deactivation of catalysts, particularly of those in the solid or fluidized state, is caused by the deposition of carbonaceous particles, such as carbon and tar or asphalt-like compositions, formed on treating the reactants, particularly at elevated temperature, on the surface of the catalyst material, thus preventing its intimate and direct contact with the reactants. In this case regeneration is effected generally by combustion of the deposited contaminants through heating the catalytic material to a high temperature in the presence of oxygen or air. Overheating of the catalyst during regeneration, however, must be carefully avoided to prevent loss in activity of the catalyst.

It is apparent that in the case of deactivation of catalysts, and in contrast to catalyst poisoning, the catalytic material is changed physically, but not chemically, by the contaminant. When free metals are used as a catalyst, oxides formed during regeneration must be reduced before further use.

Catalytic Reactions in Hydrocarbon Chemistry

Catalysis is now used in all types of reactions finding practical application in the conversion of hydrocarbons, such as:

Cracking and reforming
Hydroforming
Dehydrogenation and dehydrocyclization
Hydrogenation
Fischer-Tropsch synthesis
Polymerization
Isomerization
Alkylation
Desulfurization.

The characteristic features of these reactions will

A typical alkylation unit uses a liquid catalyst. Shown is The Texas Company unit at Port Arthur, Texas

briefly be discussed in the following paragraphs without mentioning the particular catalysts used which will be discussed later, independently.

Cracking of heavy petroleum oils, in former times only effected by thermal treatment, is now carried out largely with the aid of catalysts. Lower cracking temperatures are sufficient when using catalysts, such as temperatures between 850° and 1050° F., and decomposition of products can be made more selective, if desired. Light gas oil and gasoline fractions are produced which are generally rich in olefins and isoparaffins.

In *reforming*, naphtha, i.e. a light hydrocarbon oil, is employed as the charge material which is split to obtain light hydrocarbons with higher octane numbers.

Catalytic *hydroforming* is the catalytic reforming of heavy naphthas as obtained by topping and cracking operations. This reforming process is effected in the presence of free hydrogen. A product rich in aromatic components and free of olefiins is obtained, and the octane number, which in the charge was 50 or less, is increased to about 80-90 in the products.[5] Cracking, reforming and hydroforming are generally endothermic reactions.

Dehydrogenation and *dehydrocyclization* or aromatization are reactions serving to remove hydrogen from hydrocarbons. In catalytic dehydrogenation saturated hydrocarbons, particularly those which are normally in the gaseous state with the exception of methane, viz. ethane, propane and the butanes, are transformed to olefins, while olefins with at least 4 straight-chain carbon atoms in the molecule, such as butene-1 and butene-2, can be dehydrogenated further to form diolefins, such as butadiene. Temperatures between 660-1025° F. are employed in catalytic dehydrogenation. The olefins and diolefins thus obtained are used primarily for the production of rubber-like compounds by polymerization.

In catalytic dehydrocyclization or aromatization, hydrocarbons having at least 5 carbon atoms in the molecule in a straight chain are converted into cyclicized or ring-shaped combinations while they are dehydrogenated, toluene, for example, being formed from n-heptane in the temperature range 840-1380° F.

Catalytic *hydrogenation* serves to introduce hydrogen into the molecule of chemical combinations. Thus, olefins and diolefins can be converted in the presence of free hydrogen to saturated or at least less unsaturated hydrocarbons. The process is of particular importance for the treatment of the olefin-containing reaction products of cracking and polymerization operations, to make these products suitable for use in aviation fuel or the like. Low-grade lubricating distillates can be improved, paraffinic or aromatic gas oils converted into stable gasolines, diesel fuels with good characteristics can be obtained from low-grade distillates which are also partly desulfurized by the process. Heavy asphaltic crude oils and refinery residues can be converted into gasoline. Temperatures of about 400-500° F. can be used at normal or slightly increased pressure.

While catalytic dehydrogenation is an endothermic reaction, catalytic hydrogenation is exothermic.

The *Fischer-Tropsch synthesis* for the production of hydrocarbons, particularly those higher than methane, from a mixture of carbon monoxide and hydrogen at moderate temperatures (about 375-500° F.) and moderate pressures (generally between 0-150 psi.) is a specific type of hydrogenation, the oxygen of carbon monoxide combining with hydrogen to form water while its carbon atoms unite with one another and with further hydrogen in forming a hydrocarbon chain. Accord-

ing to the amount of hydrogen present the hydrocarbons formed will be either unsaturated or saturated, e.g.;

$$2CO + 4H_2 \rightarrow H_2C = CH_2 + 2H_2O$$
$$H_2C = CH_2 + H_2 \rightarrow H_3C - CH_3$$

This process is exothermic.

Catalytic *polymerization* is used to combine two or more molecules of unsaturated hydrocarbons, particularly olefins or diolefins, in order to form hydrocarbons of higher molecular weight. Dimers (from two molecules of the monomer) or polymers up to such formed by the combination of a very large number of monomers can be formed. The monomer molecules used in the formation of polymers can either be all of the same kind, or different olefins can be combined to form copolymers. By dimerization of butene, octene is formed which on hydrogenation gives octane, very important in the production of aviation gasoline. By polymerization of numerous molecules of olefins or diolefins, such as ethylene or butadiene, plastics and rubber-like compounds can be obtained. The conditions of treatment vary considerably according to the type of product desired. Catalytic polymerization is an exothermic reaction.

Catalytic *isomerization* is a process which causes a rearrangement in the carbon chain of normal paraffins and olefins to form so-called iso-hydrocarbons, such as isobutane from n-butane or isobutylene from butene-1 or butene-2, the straight chain: C-C-C-C being changed to C-C-C. A temperature of about 150-210° F. and increased pressure (200-350 psi.) can, for example, be used in the catalytic isomerization of n-butane. Isomerization of paraffinic hydrocarbons results in the production of hydrocarbons of higher anti-knock rating. The octane number generally is the higher, the more branched the hydrocarbon molecule is.[6] Another very important purpose of isomerization is the production of reactants for alkylation processes.

Catalytic *alkylation* is effected by uniting one mole of an olefin with one mole of an isoparaffin or aromatic hydrocarbon, a hydrocarbon with a correspondingly larger molecule being formed:

$$H_3C - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_3 + H_3C - CH = CH - CH_3 \rightarrow$$

ISOBUTANE BUTENE

$$H_3C - \underset{\displaystyle CH_3}{\underset{|}{C}} - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_2CH_3$$

ISOOCTANE

Saturated hydrocarbons of an isostructure are thus formed and these hydrocarbons, such as isooctane itself, are characterized by their high octane numbers. The molecular proportion of isoparaffin employed in the process has to be considerably higher than that of olefin to prevent or substantially decrease polymerization of the latter. Ratios of isoparaffin to olefin of 2.5:1 to 7:1 and still higher are employed. The reaction conditions can vary considerably according to the particular catalyst used, temperatures as low as 32° F. and still less being useful in some cases while such up to more than 100° F. are employed in other cases. The process is exothermic.

Catalytic *desulfurization*, as any desulfurization of hydrocarbons, serves to eliminate undesirable odors and corrosive properties of petroleum hydrocarbons caused by their content of sulfur compounds, and to increase the lead susceptibility of hydrocarbons. The organic sulfur compounds contaminating petroleum hydrocarbons, e.g. mercaptans and mercaptides, are transformed under the influence of a catalyst and in the presence of hydrogen into easily removable inorganic sulfur combinations, particularly hydrogen sulfide (H_2S). Temperatures of about 650-750° F. are employed for preheating the charge material in this exothermic process. The sulfur content of a hydrocarbon stock can be reduced by catalytic desulfurization, for example, from about 5.0 percent to about 0.5-0.1 percent and even less.[7]

Catalysts Used in Catalytic Conversion, Synthesis, and Refining of Hydrocarbons

As mentioned before, the number of catalysts useful in the conversion, synthesis and refining of hydrocarbons is great. The number of those finding commercial application in industry is comparatively small for one reason or the other, and it is interesting that one and the same kind of catalyst can be used for various of the processes, though in part under different conditions. This illustrates that the catalysts employed, which generally are of inorganic or partly inorganic nature, are not very specific in their action, in contrast particularly to most of the enzymes produced and employed by and in living matter. It is for this reason that the catalysts of main importance in the petroleum industry are here discussed grouped according to their chemical classification rather than to the processes of their application.

a) Silica and Alumina and Compounds Containing Them

Among the insoluble oxides silica and alumina and compounds containing them are of outstanding importance in their use as catalysts. They are employed either as gels or are activated by a pretreatment with acids, alkaline liquids, or the like, particularly in order to increase their surface, and they can either be used as natural products containing silica or alumina, or both, in a cleaned, activated, granular or shaped form of predetermined mesh size, or they can be chemically produced. Of natural products clays, bentonite, and bauxite are of first class importance.

Silica gel and alumina gel, or a mixture of the two can be formed by treatment of aqueous solutions of their soluble salts, such as sodium silicate or aluminum sulfate, with precipitating agents, e.g. mineral acids in the first case and ammonia or other alkali in the second case. The hydrogels thus obtained are transformed to gels by thermal treatment.

Silica and alumina gels, activated clays, such as fuller's earth, bauxite, bentonite and acid activated bentonite are particularly used in cracking processes, but also in the isomerization of olefins and the like. Such clays are employed further for polymerization,[8,9,10] e.g. of diolefins, and in desulfurization,[11] where bauxite is also useful (Perco process).[12] Dehydrogenation can also be effected by means of alumina.[13] The same catalysts thus prove effective in processes of very different nature, some of them (cracking and dehydrogenation) being endothermic while others are exothermic (polymerization and desulfurization). The usefulness of the same catalysts in these different reactions leads to the conclusion that the action of the catalysts here seems to be of a more physical nature, perhaps of the kind thought of in Whitmores' carbonium-ion or hydrogen-ion theory. (See above.)

Various additional materials and promoters are employed in combination with catalysts of this type, particularly with silica and/or alumina. Such additions are oxides of numerous metals, such as those of calcium, magnesium, chromium, zirconium, vanadium, thorium, tin, beryllium, iron, copper and boron, while the oxides of bismuth, cerium, cadmium, boric acid, and ferric

chloride have been suggested as promoters in catalytic cracking. The additional metallic compounds can either be intimately mixed mechanically with the basic materials of the catalyst, or gels of silica or alumina can be impregnated with solutions of the metals in question whereupon their oxides are precipitated on the silica or alumina carrier by suitable means, e.g. alkaline solutions, or the metal oxides can be formed simultaneously with the alumina or silica gel by co-precipitation.

When using alumina in dehydrogenation processes the oxides of chromium, iron, or zinc, vanadium sulfate or reduced metallic nickel can advantageously be used as promoters,[13,14] alumina at the same time serving as carrier for them.

b) Other Insoluble Oxides and Their Compounds.

Titanium oxide on a silicate carrier or in admixture with boron oxide can be used as a catalyst in cracking and other operations.[10,41,42]

For dehydrogenation, chromic oxide (Cr_2O_3) either alone or combined with alumina by co-precipitation or impregation is of particular importance.[14,15] Cerium oxide can be used as a promoter for chromium oxide catalysts. A mixture of magnesia, iron oxide and potassium oxide used in the presence of steam has also been proposed for this purpose (Kearby). Copper oxide can be added as a stabilizer. The addition of a small amount of carbon dioxide (CO_2) prolongs the activity of this and other dehydrogenation catalysts.[24]

Molybdena is also used in dehydrogenation and in hydroforming, in the latter case particularly supported on alumina in granular or pellet form.[5] This catalyst has also a desulfurizing action. Nickel oxide, too, is used in desulfurizing cracked petroleum products.

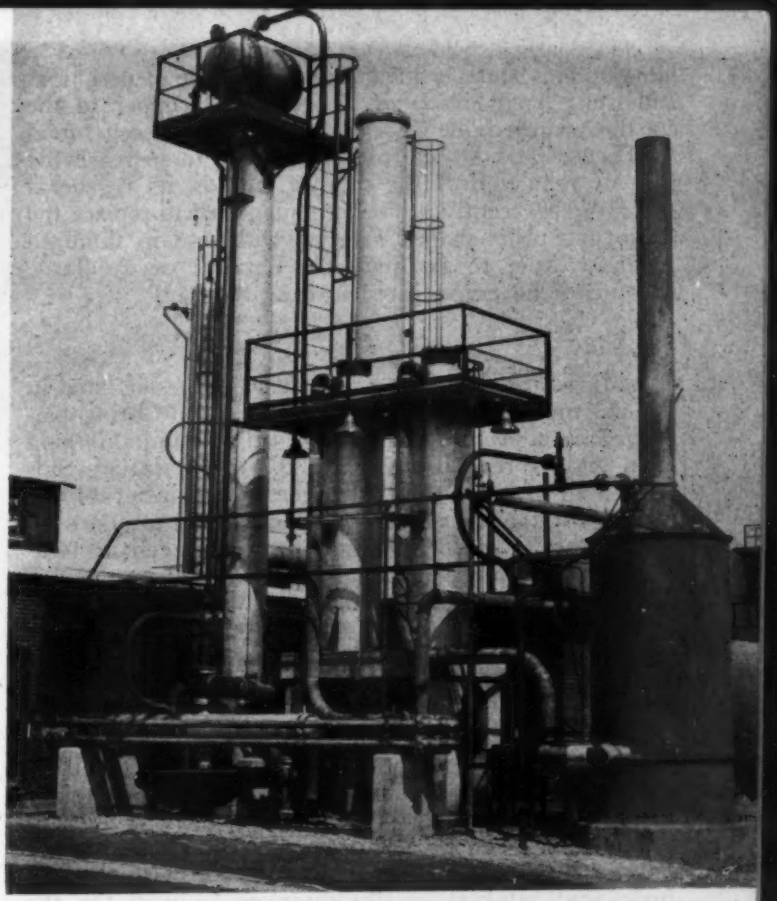
c) Metal Sulfides.

Molybdenum sulfide and tungsten sulfide are used as catalysts in hydrogenation-cracking and in hydrogenation proper.

d) Metal Salts.

Of outstanding importance in the conversion and refining of hydrocarbons are the so-called Friedel-Crafts catalysts, i.e. in first line the aluminum halides, iron halides, etc. Most important among them is aluminum chloride ($AlCl_3$). It forms one of the main catalysts used in polymerization of olefins as well as in isomerization of paraffins. In both cases it is used in the anhydrous state. Hydrochloric acid is generally added as a promoter. Other promoters and additions employed are other metals, their oxides and salts, such as Ni, Cu, and their halides,[18] or antimony trichloride ($SbCl_3$).[11] Instead of $AlCl_3$ the bromide $AlBr_3$ is recommended as still more effective, and a recent patent suggests its use in the liquid phase isomerization of n-butanes.[23] To obtain most intimate contact with the reactant, the aluminum chloride can be vaporized together with the hydrocarbon to be isomerized and then condensed in the presence of the hydrocarbon vapors.[25]

Friedel-Crafts catalysts are also in use in alkylation, particularly in the alkylation of cyclic compounds with olefins. It is for this field that the English scientists Friedel and Crafts originally proposed this kind of catalyst. Numerous additives and promoters are recommended, such as alkali halides, hydrogen halides, and the like. Bauxite, silica gel and other solids, such as kieselguhr, are sometimes used as carriers, particularly where a stationary bed of catalyst material is desired. Complexes of aluminum halide with hydrocarbons formed by heating, for example $AlCl_3$ with a hydrocarbon, have



Shown is a plant in Pennsylvania for the catalytic polymerization of the olefins in mixed refinery gases. The catalyst used here is in solid form, phosphoric acid on a Kieselguhr support.

proved useful, as have solutions of $AlCl_3$ in nitroparaffins (Schmerling). Even in the catalytic cracking of gas oil to form motor fuels aluminum chloride has been used successfully (McAfee process). Instead of $AlCl_3$ the salt $AlCl_2F$ has also been proposed for cracking purposes.

Multivalent phosphate in admixture with aluminum fluoride, alkali phosphates, tungstates and molybdates, heavy metal manganates and permanganates are recommended as cracking catalysts.

A cobalt molybdate catalyst finds application in desulfurization by hydrogenation. It can be used supported on alumina in the form of pellets. It excells in abrasion resistance and heat stability and retains its activity after calcination in air at a temperature of 1470° F.[7]

e) Free Metals.

Free metals are used as catalysts in hydrogenation and in the Fischer-Tropsch hydrocarbon synthesis. While in the first case nickel is the metal primarily employed,[20] preferably supported on an inert carrier like unglazed porcelain, iron, cobalt, nickel and ruthenium are the metal catalysts used in the Fischer-Tropsch synthesis. They are preferably used in connection with small quantities of alkali oxides or salts, or the like, as promoters.[21,22] A mixture of nickel or cobalt with thorium oxide on kieselguhr is of particular importance.[22] These catalysts are prepared by suspending kieselguhr in water, adding nickel or cobalt nitrate and thorium nitrate, precipitating the oxides of these metals with soda and coagulating the oxides in the kieselguhr. After washing and drying the mass, the nickel or cobalt oxide is reduced to metal in a hydrogen stream at 660° F.[21,22] Alumina, tungstic oxide, or uranium oxide can be employed instead of thoria, and manganese oxide can be added. A nickel-manganese-alumina complex precipi-

tated on kieselguhr is advantageous because of its longer activity.[22] An addition of 2 percent of copper to the cobalt-thorium oxide-kieselguhr catalyst has been found by Fischer and his co-workers greatly to increase the ease of reduction of the catalyst, also in its regeneration.[22] Very recently it has been suggested to replace the stationary pellet-shaped catalyst with one in fluidized form in order to facilitate the removal of the large amount of heat generated in the process.[43]

f) Acids.

Sulfuric acid is used as a catalyst on the one hand in the polymerization of olefins, silver sulfate being employed as a promoter.[26] On the other hand this acid is in wide spread use as an alkylation catalyst. Sulfuric acid of more than 90 percent and preferably of 98 percent concentration is employed and mixed with the isoparaffins. The olefins are introduced at temperatures of about 50-100° F. into this mixture.[11, 27, 28] Mercury compounds, chloro or fluorosulfonic acid, carboxylic acids, cuprous chloride, and the like are employed as additions, sulfates of nickel, cobalt, silver, or copper, and selenium oxide (SeO_2) as promoters.

More recently anhydrous hydrofluoric acid (HF) has come into use in alkylating processes, either alone [11, 29] or in combination with boron fluoride (BF_3).[30, 31] Alkyl fluoride,[32] an iron-nickel alloy,[33] etc., can be used as additions. BF_3 and other boron halides can also be used in combination with the sulfuric acid catalyst in alkylation reactions.[34] On the other hand a solution of BF_3 can be used as the sole catalyst instead of HF for the same purpose.[35] Very recently a catalyst comprising hydrofluoric acid and metallic aluminum as a promoter has been suggested as a cracking catalyst at temperatures of 150-400° F. and under a pressure sufficient to maintain the HF and the hydrocarbons in the liquid phase.[36] A liquid mixture of HF and BF_3 is also proposed for this purpose while working under similar conditions of temperature and pressure.[37] The hydrofluoric acid catalyst can easily be recovered and purified by distillation, due to the low b.p. of HF, viz. 68° F.

Phosphoric acid, particularly in the solid state, supported on an inert carrier, such as magnesium sulfate or kieselguhr, is used as the catalyst in polymerization reactions instead of sulfuric acid.[11] Metal oxides or salts can be added as promoters. Instead of the free acid, a pyrophosphoric acid salt, e.g. sodium pyrophosphate can also be used.[11]

Heat Control in Endothermic and Exothermic Processes

The heat developed in the exothermic regeneration of catalysts, particularly in the combustion of carbonaceous deposits on solid catalysts, can be used in the preheating of charge stock and in the heat control for the catalytic process proper. For exothermic hydrocarbon conversion processes, such as hydrogenation, polymerization, etc., it is important to take care that the heat developed in the catalytic process is closely controlled or removed. In order to prevent an excessive rise in temperature in such cases it has recently been recommended to introduce subdivided solid catalyst during the reaction at a temperature substantially below the conversion temperature and in sufficient amount to absorb at least the major portion of the exothermic heat of reaction.[38]

For endothermic catalytic processes the admixture of inactive heat absorbing material to solid cracking or dehydrogenation catalysts is recommended. The additional materials may either be such of inherently high heat capacity and/or such of moderate heat capacity and high density. In any case these materials shall be catalytically inert. Metallic iron or nickel, fused alumina, and other metal oxides, magnesite brick, chrome brick, bentonite, carborundum, quartz, and the like are named for this purpose. The heat absorbing materials are intimately and uniformly associated with the solid catalysts, and the combined masses are regenerated in the same manner as the catalysts alone.[39, 40] The exothermic heat of regeneration is stored in the admixed inactive heat absorbing material and used in the subsequent endothermic catalytic process.

Conclusion

The discussion of catalysts and their application in hydrocarbon chemistry shows that our knowledge in this field is mainly of mere empirical nature. As a rule it cannot be predicted from the known chemical and physical properties of substances whether or not they will work as general or specific catalysts. It is by experiment only that the catalytic properties of substances can be determined. Thus, it seems, for example, that no conclusive reason can be given at present for the fact that numerous oxides and salts, such as the halides of three-valent metals, show excellent catalytic properties for certain hydrocarbon conversions, and why some of such oxides or salts are more effective than others. Only in some cases can conclusions cncerning the catalytic effect be drawn from the properties of chemical substances. Thus the excellent catalytic effect of silica and alumina may be caused, at least in part, by their property to form gels with large effective surface. No real knowledge exists concerning the cause of the action of promoters and other additives.

Much investigation will, therefore, still be required to develop a real science from our far spread empirical knowledge of catalysts and catalysis in hydrocarbon chemistry.

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Maintenance of Cooling Towers

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THIS article contains information which obviously could be assembled only as the result of years of practical experience in the field. It is one of the very few articles which ever have been published on the subject, and should prove especially valuable to plant operators and engineers.

COOLING tower maintenance is a subject which, in the past, has not received sufficient attention from plant operators. In most plants there is a program of preventative maintenance for all operating equipment, and such a program should certainly be extended to include cooling towers. There is little doubt the inaccessible location of most towers, either on a roof or on the outskirts of the plant, is responsible for this. However, it should be remembered that an adequate supply of cold water is most essential for satisfactory and efficient plant operation.

The very principles upon which the cooling tower functions, also gives rise to the problems of its maintenance. For instance, in order to obtain the desired cooling of circulating water, it is necessary that evaporation take place, and this creates a new problem by increasing the salt content of the water.

In order to perform satisfactorily, cooling towers are usually installed in open, unobstructed areas where wind velocities are such as to allow dust, dirt and debris to be carried along. Since the air passes through the tower over which water is falling, the debris would be washed out of the air and into the basin, and another problem is created.

In order to keep the salt content of the water in the basin to an absolute minimum, and also to remove any collected dirt, dust, and other debris from the basin, it is recommended that a continuous blowdown be made a part of the cooling tower system, and that the tower be scheduled for periodic shutdowns so that the internal filling of the tower and the basin can both be cleaned.

Water Treatment

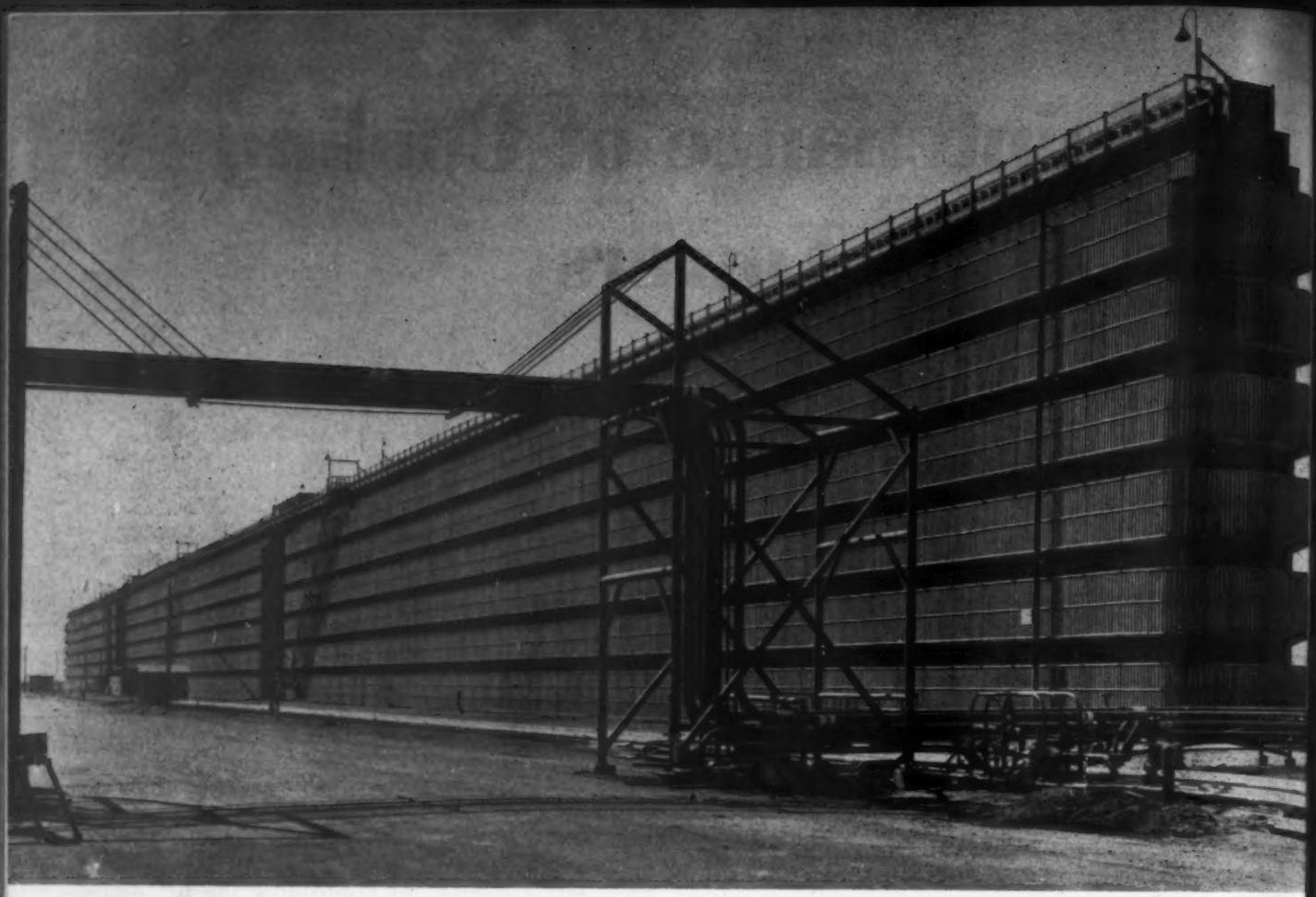
Maintenance of a cooling tower, exclusive of any mechanical equipment, is closely associated with the quality of the water used. It is therefore almost impossible to discuss cooling tower maintenance without discussing cooling water treatment. The problem of water treatment is an entire field in itself. The general opinion of plant operators presented herein is not intended to be a solution to a specific water treatment problem, but is to be used only as a guide. For specific problems, it is recommended that any one of a number of companies specializing in water treatment be contacted. Briefly, however, water treatment is done to control algae, to control scale formation, and to prevent deterioration of the materials used in the construction of the equipment.

Many operators have found chlorine to be one of the most suitable agents for the control of algae. In many plants satisfactory algae control is obtained by injecting six to eight pounds of chlorine per day for each 1000 gpm. circulated. If this amount is consistently added to the water, however, a type of algae immune to chlorine soon will develop. Therefore, every ten days or so for a short period of time the amount of chlorine supplied to the system should be increased several times, thus preventing this chlorine immune algae from developing.

Generally speaking, by controlling the pH of the cooling tower water, it is possible to control the rate of scale deposition in piping and on exchanger tubes. The higher the pH of the water, the greater the tendency for a scale to deposit. When the pH is below seven, little or no scale deposition occurs; rather, the metals in contact with the water slowly begin to dissolve. The latest most satisfactory practice is to keep the pH of the water between 6.5 and 7, and then to add a corrosion inhibitor to the system. This keeps the piping and exchanger tubes clean, and prevents the metal from corroding. However, the above treatment should only be attempted under the advice of a water treating specialist.

In certain areas in west United States, the water tends to be very alkaline due to the presence of sodium, calcium, and magnesium salts occurring in the form of bicarbonates. This situation is further aggravated as the cooling tower tends to concentrate the salts in the system. It has been found that when the pH of the water is over 9.0, and when large amounts of bicarbonates are present, the structure of the wood in the cooling tower may be seriously affected. It is particularly noticeable where the wood is alternately wet and dry, a condition which occurs on the sides of an atmospheric tower. At these points the bicarbonates concentrate, and turn into normal carbonates. The carbonates attack and dissolve the lignin in the wood, producing an effect which is termed delignification. This is evidenced by a soft spongy, stringy wood structure which appears to be decayed. The only way delignification can be absolutely prevented is to remove the bicarbonates from the circulatory system. This is impractical in many cases. However, plant operators report delignification can be controlled by keeping the pH of the water below 8.5.

Once the importance of the water problem is un-



Atmospheric cooling towers, where such application proves practical, provide efficient cooling at low utility cost and low maintenance requirements.

derstood, the operator should next consider the scheduling of a regular inspection and maintenance program for his cooling equipment. This regular inspection program should include the distributing system, filling, outside covering (paneling, louvers or aerators and drip panels), framework, basin, drift eliminators, coilshed sections and mechanical equipment.

Distributing System

The importance of maintaining the distributing system at peak efficiency cannot be over emphasized. The function of the distributing system, as the term indicates, is to distribute the water uniformly over the top of the tower, and, to break it up into fine particles in order to expose as much water surface as possible to the air. There are four general types of distributing systems in common use today, namely, the upspray, the downspray, the flume systems and pantype systems. Before discussing these, however, it is well to point out that, regardless of the type of system employed on new towers, it will be necessary to inspect the nozzles every week or two for the first three months of operation. This is to make sure that wood splinters, shavings or other debris normally found in a new tower have not plugged some of the nozzles.

The *upspray system* consists of a central header with pipe sidearms to which, at regular intervals, are attached the upspray nozzles. This system ordinarily operates at five to six pounds nozzle pressure, and depends on centrifugal force rather than small orifices for fine breakup of the water. The nozzle orifices are usually about one inch in diameter. This large opening, together with the five or six pounds pressure drop is sufficient to prevent algae, small rocks and sand from plugging the nozzles. The system is usually located about six or eight feet below the drift eliminators on mechanical draft towers, and about the same distance from the top of an atmospheric tower. The nozzles spray up and completely fill the spray chamber with finely divided water. This type of system will distribute the water uniformly with a wide variation of water flow. This system requires a minimum of attention, but should be inspected every nine to twelve months and any obstructions in the nozzle should be removed. This inspection, of course, is predicated upon the fact that the customer inspects the system as mentioned above during the first two or three months of operation.

The *downspray system* consists of a central header with pipe sidearms to which, at regular intervals, are attached downspray nozzles. This system is usually located as close to the top of the tower as possible and operates on about 1½ lbs. nozzle pressure. Because of the low pressure, the nozzle must operate on the principle that water impinging on a plate will be distributed evenly. This system will perhaps not keep itself quite as clean as the upspray system, however, it too will uniformly distribute water with a wide variation of water flow. This system should also be inspected every three to six months.

The *flume type system* is composed of a main flume extending around the outside of the cell with interconnecting side flumes. This flume is usually constructed of wood. In the bottom of the flume, holes

are usually bored into which are inserted plastic discharge tubes. Two to three feet directly below each discharge tube is a plastic splash plate upon which the discharge stream from the flume impinges. The effect of the stream of water falling on this plate causes a splashing action which distributes the water. This system is not as flexible as the two types previously described. At high water rates the flumes overflow and at reduced water rates the water is not uniformly distributed. A continual maintenance problem is presented. Because the flumes tend to open up at the seams, they require leveling, and the splash plates have to be renewed periodically as well as adjusted so that the stream of water impinges directly on the center of the disc. The flumes form an ideal place for sludge, algae and sand to accumulate and therefore they require frequent cleaning. Also, since the algae growth varies with the water temperature the open flumes offer an ideal place for its growth. This type should be inspected every 30 days and repairs made immediately. If allowed to get into a state of disrepair, the performance of the tower will be seriously affected, and repair costs will be increased.

Another type of flume system is the *open pan type,* which covers the effective part of the cooling tower. Here a large number of small nozzles, operating at an extremely low water head, are used. These easily become plugged with small debris. This type is susceptible to increased algae growth, due to the hot water temperature, and to its exposure to direct sunlight. By placing a cover over the distributing system, much of the debris blown in by the wind can be eliminated. This will also retard algae growth, since it shields the water from direct contact with sunlight. If covers are provided for the system, inspection should be made every two to three months; if not, inspection should be made more often.

Filling

The function of the filling is to increase the contact between air and water, primarily by offering new exposed surface to the air as the water cascades through the tower. Another function is to maintain proper distribution of both air and water. Its efficiency is affected by oil, dirt, algae and other foreign materials, and it is, therefore, important that the filling be kept clean. A filling composed of flat horizontal slats is more subject to the collection of foreign matter than are the decks composed of vertical or sloping slats. Sagging filling tends to concentrate the water in the areas of the low spots of the fill. This in turn causes air channelling since the air will not as readily pass through areas of high water concentration as through areas of low water concentration. This air channelling reduces the contact between air and water, thereby reducing the performance.

A number of different types of filling are used. In general, they fall into two classes; the grid type and the slotted lath type. The grid type consists of boards or battons nailed upon cleats to form panels. These panels or grids are usually substantial enough to function as scaffolding during the period of erection, and are convenient to walk upon when cleaning and inspecting the tower. The grids are easily removed and are substantial enough to be cleaned with a fire hose.

The slotted lath type of fill consists of slotted lath, through which are threaded other lath. This type of filling is not nailed and should not be walked upon. It also cannot be readily removed nor should it be cleaned with a fire hose.

The presence of oil in the cooling tower water is detrimental to tower performance, because oil-soaked filling will not be wetted by water. This results in improper breakup of the water and a reduction in the wetted surface exposed to the airstream. Oil deposits have been removed from the filling by means of solvents and steam. However, it is usually cheaper to replace the filling.

Algae growth probably contributes more to reduce the performance of cooling towers than any other factor. Once algae has made headway there is little to do but to shut down the tower for a thorough cleaning job. This is usually accomplished by means of a fire hose and/or circulating a strong chemical solution. This should be immediately followed by a flushing and draining of the entire cooling system to prevent fouling of the heat exchange surface by the dead algae.

Cooling Tower Basins

Cooling tower basins are usually constructed of concrete, however, they are also made of redwood and steel.

Occasionally the water circulated in the tower will have a detrimental effect on the concrete basin; in such cases, it has helped to plaster the basin with an asphaltic base material similar to roof putty.

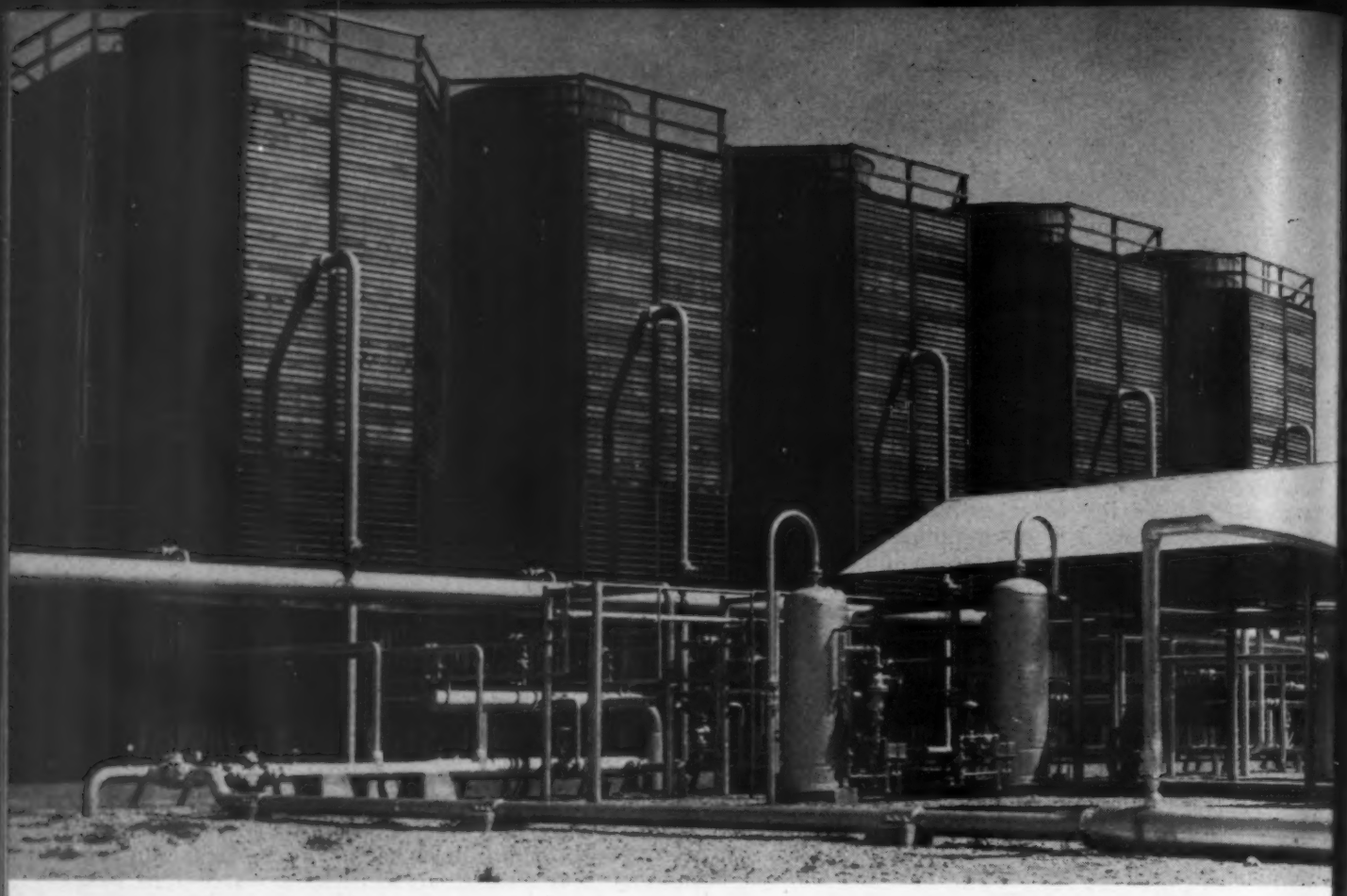
When cooling tower basins are constructed of redwood, it is difficult to maintain a water-tight basin. This is particularly true when a tower is used seasonally such as in connection with an air-conditioning system. A redwood basin should never be allowed to dry out, as a change in moisture content of the wood is followed by a change in its dimensions. If redwood is allowed to dry and shrink, and then to soak and swell, it will be found that the wood will never quite revert to its former dimension. Therefore, if this wet and dry cycle is repeated very many times, it will be found that the basin will no longer be water-tight. This also applies to redwood stave pipe. Redwood stave pipe is often used as a primary distributing header and should not be allowed to dry out. Also, the reinforcing bands should be kept tight at all times to prevent leakage.

One of the best ways of stopping a redwood basin from dripping is to add shredded asbestos, similar to the fiberous insulating material used in plastering fractionating columns, to the area of the basin containing the leak. This shredded fiberous material will then migrate to the area of the leak and it will flow into and seal the crevice.

Suction pit screens should be incorporated in all cooling tower basins. They strain extraneous matter out of the cooling system, and do much to reduce the maintenance of the circulatory system.

An attempt should always be made to keep the water level in the basin above the level of the anchor bolts, and anchor castings. The interfacial surface between the air and water has been found to be very corrosive. Inspection shows accelerated corrosion to occur at the water line when very little, if any, occurs above and below this point.

Because failure of any part of the mechanical equipment (such as the fan, gears, or flexible coupling and floating shaft) will shut down the unit, it is important that a regular inspection and main-



Induced draft cooling towers provide for large loads with small space requirements, and afford a high degree of operating flexibility and control.

tenance program be adopted. Here is a minimum service schedule for the various pieces of apparatus.

Gear. The oil level in the gear should be checked every 30 days. If it is found that the level has gone down, the gear case and oil seals should be checked for leaks, and appropriate steps taken to correct them. If, on the other hand, the oil level appears to have risen, drain a one quart sample from the bottom of the gear case and check for emulsification and contamination. Because the gear on an induced draft tower is located in a hot humid, air stream, condensation of moisture may occur in the gear case. This is particularly true in towers which are operated intermittently. Should there be any signs of emulsification, the oil should be drained and refilled with the type of lubricant recommended by the manufacturer. Also, an inspection should be made of the oil seals, particularly the oil seal on the slow speed shaft. Since oil seals are normally inserted in a small recess in the housing, it collects the moisture condensed on the fan shaft. Any failure of the seal, or corrosion on the shaft at this point, will permit the collected water to enter the unit.

An oil sample should be drained from the bottom of the gear case every three months. Again, if the oil shows any sign of emulsification, contamination, or deterioration, it should be drained and refilled. The oil should be drained and refilled every six months with the exact type of lubricant recommended by the manufacturer.

Regular Examination

Once a year the oil seals on the gear should be examined and replaced if necessary. Also, the bearings should be checked for play, particularly the bearings on the fan shaft where the greatest wear usually occurs. This can easily be checked by rocking the fan blade up and down. If any appreciable wear has occurred, the bearings should be either adjusted or replaced. Where oil is found to be emulsified in the gear unit, indication of excessive wear will usually be found on the lower slow-speed shaft bearing. This is because on some reducer designs sufficient sump capacity for collecting water and sludge is not provided below the lower main bearing. If this condition exists, some relief can be obtained by substituting a large capped reducing nipple for the drain plug in the center of the gear case, thus allowing room below the bearing for the water to settle.

Couplings. The floating shaft couplings used on cooling towers fall into three classes; gear types, metal, fabric or rubber disc type, and the universal joint type.

The gear type coupling should be taken apart and inspected once a year. The lubricant, together with any contaminates, should be drained and discarded. The teeth on the coupling should be washed with kerosene and examined for wear before reassembling. Care should be taken in the choice of a lubricant for this gear type coupling since it operates in a hot, humid air stream and there is danger of moisture condensing inside. As moisture condenses, the centrifugal action of the revolving coupling causes the water to displace the lubricant in the periphery of the housing. Since the gear teeth are also located on the housing periphery, serious wear may occur because of lack of lubrication. Because of this it is recommended that the lubricant used be of the water proof

type whose specific gravity is greater than that of water.

The disc type coupling should be examined every six months for cracks and breaks in the fabric or metal discs. Should they show any signs of wear, the discs should be immediately replaced. It is recommended for all couplings, that heavy strap iron guards be made for each end of the floating shaft to confine the rotation of the shaft should the couplings fail. This is done to prevent the loose end of the shaft from whipping around and damaging the fan, as well as the motor and gear shafts.

The universal joint type coupling requires lubrication every three to four weeks. This type of coupling requires a heavy oil rather than a grease. Properly lubricated, this type of coupling will give by far the best service of any of the couplings previously mentioned since its greater flexibility better adapts it for use on a wooden structure which is not rigid.

The gear and motor should be checked for proper alignment once a year. The following procedure for aligning floating shaft couplings is recommended:

The floating shaft and couplings should be removed, leaving a flanged hub on both the motor and gear shaft. Stretch a fine copper wire or chalk line over the top of both the motor and gear flange. Next, check with a square against the flange face and wire, first on one coupling and then the other. The square will show any misalignment. This should be done both with the wire or chalk line on top of the coupling and on the side of the coupling. Shifting of the motor and gear and shimming will make one edge of the square parallel with the wire in both positions. When this is accomplished, the unit will be in proper alignment.

Fans. The fan blades used on cooling towers fall into three classes: 1) fabricated carbon or stainless steel, 2) cast aluminum, or 3) airplane wing section type.

Once a year the fan blade arms should be examined for fatigue cracks; this applies to all classes of fans. The fabricated stainless steel fan should require little or no maintenance while the carbon steel and aluminum fan blades may be scraped and coated each year or two with a preserving material. On the other hand, carbon steel and aluminum fans have been known to give five to ten years of service with no blade maintenance work.

The airplane wing type of fan blade consists of struts covered with fabric or metal. This type should be examined every three to six months for tears or rips in the covering. Should this occur, repairs should be immediately made lest the entire fan be destroyed.

A fan will become sufficiently unbalanced in normal service to require rebalancing every three to five years. This occurs because of the uneven erosion, corrosion, or deposition on the blades over a period of years. Very often, vibration on top of a cooling tower will be blamed upon the fan, when in reality, it is due to misalignment of the gear and motor. These two vibration sources can be readily distinguished. The vibration caused by an unbalanced fan will give a swaying motion to the tower because of its relatively great mass and slow speed, while the misalignment of the motors and gears will cause a high speed vibration which makes a rapping sound.

Conclusion

The following is a minimum maintenance schedule for an atmospheric tower:

Once per week—Inspect suction pit screens and clean as required.

Once per month—Inspect flume type distributing systems and clean as required.

Once every three months—Inspect and clean downspray distributing system.

Once every six months—Inspect and clean upspray distributing system.

Once per year—Shut down tower and thoroughly clean, particularly the distributing system, filling and basin. A thorough inspection of the structure together with the filling, louvers and aerators should be made at this time. Any repairs required should be made immediately. Should the tower contain a flume type distributing system, it should be releveled and also repaired as required.

Mechanical Draft Tower

The minimum maintenance schedule for a mechanical draft tower is outlined below:

Once per week—Inspect suction pit screens and clean as required.

Once per month—1) Check oil in gear case for level and contamination. 2) Lubricate universal joint type couplings. 3) Inspect and clean flume type distributing systems.

Once every three months—1) Check downspray distributing system and clean if necessary. 2) Inspect disc type couplings for fractures in discs.

Once every six months—1) Drain and refill gear case with recommended oil. 2) Lubricate motor bearings. 3) Check upspray distributing systems.

Once per year—The tower should be shut down and thoroughly cleaned from top to bottom, including the basin. A thorough inspection of the structure should be made, together with the necessary repairs and replacements. Should the tower contain a flume type distributing system, it should be releveled and repaired at this time. The mechanical equipment should be checked for alignment and the bolts anchoring this equipment to the tower should be tightened. The fans should be inspected and repaired as required. The gear type couplings should be opened up for inspection and serviced and the gear box bearings and seals examined for wear.

* * *

FELIX HEINEMANN

Refiner Hears From Another Heinemann

THE author is new but he bears a family name quite familiar to PETROLEUM REFINER readers.

Reference is to Dr. Felix Heinemann, whose article "Catalysts in Petroleum Refining" commences on page 138 of this month's issue.

Dr. Heinemann's son, Heinz Heinemann, is the fellow who, month after month, has been presenting for REFINER readers a digest of all U. S. patents pertaining to petroleum refining, (page 138 in this issue.) So the name is well known.

Felix Heinemann was graduated with a Ph. D. degree from the University of Berlin and has worked as a research and industrial chemist both in the United States and abroad, his activities covering varied fields of chemistry. For many years he was a German patent attorney specializing in chemistry. He also was patent counsel for large petroleum and coal companies, handling their U. S. and foreign applications. Among the many famous scientists he has represented appear the names of Franz Fischer and Hans Tropsch.

During the past few years Heinemann has worked as a consulting chemist and has prepared patent and literature searches and abstracts. Reading several European languages, he has been active as a technical and scientific translator. He is an abstractor for Chemical Abstracts and a member of ACS. Chemistry runs in the family for his son also is a chemist.

One of Dr. Heinemann's favorite pastimes is hiking in the countryside around Philadelphia, where he resides at 6722 Wyncote Avenue. He has a strong interest in the arts and once owned a fine collection of etchings. He confesses that his real love, however, is the study of philosophy and science.

Krebs is Graduate Of Illinois School

DR. ROBERT W. KREBS, author of "Applications of the Fluid Catalyst Technique to Catalytic Cracking and Hydrocarbon Synthesis" (page 115) was born on June 10, 1912, in London, Wis. His scholastic training was received at the University of Illinois, where he received the B.S. (1933), M.S. (1935), and Ph.D. (1937) degrees in Chemical Engineering. During the period December, 1933, to January, 1937, he served as part-time assistant in chemistry, teaching inorganic chemistry to undergraduate students at the University of Illinois. Also, while at Illinois, he did control work in pilot plant operations at the Engineering Experiment Station there.

Dr. Krebs began his professional career with the Standard Oil Company of New Jersey in March, 1937, when he was employed as a chemical engineer at the Esso Laboratories. He has worked in the fields of catalytic cracking, butadiene production and synthetic rubber production. He made important contributions in all of these fields, particularly during the critical war years. More recently Dr. Krebs has been engaged in work on the hydrocarbon synthesis process and in the development of new types of catalysts.

Dr. Krebs is at present an associate director of the Esso Laboratories, Esso Standard Oil Company (Louisiana Division).

Dr. Krebs is married and he and his wife have two lovely daughters that manage to keep things active and interesting around home.

H. A. HULSBERG

B. H. WEIL

Writing is Termed Weil's Chief Hobby

"DETERGENTS from Petroleum," which starts on page 126 of this month's issue of PETROLEUM REFINER, was contributed by B. H. Weil, chief of the Technical Information Division of the Georgia Tech Engineering Experiment Station, Atlanta, Ga., and editor of its bi-monthly journal, "The Research Engineer." Weil is joint author of three recent books, "Synthetic Petroleum from the Synthine Process," "Plastic Horizons," and the "ABC of Chemical Derivatives from Petroleum."

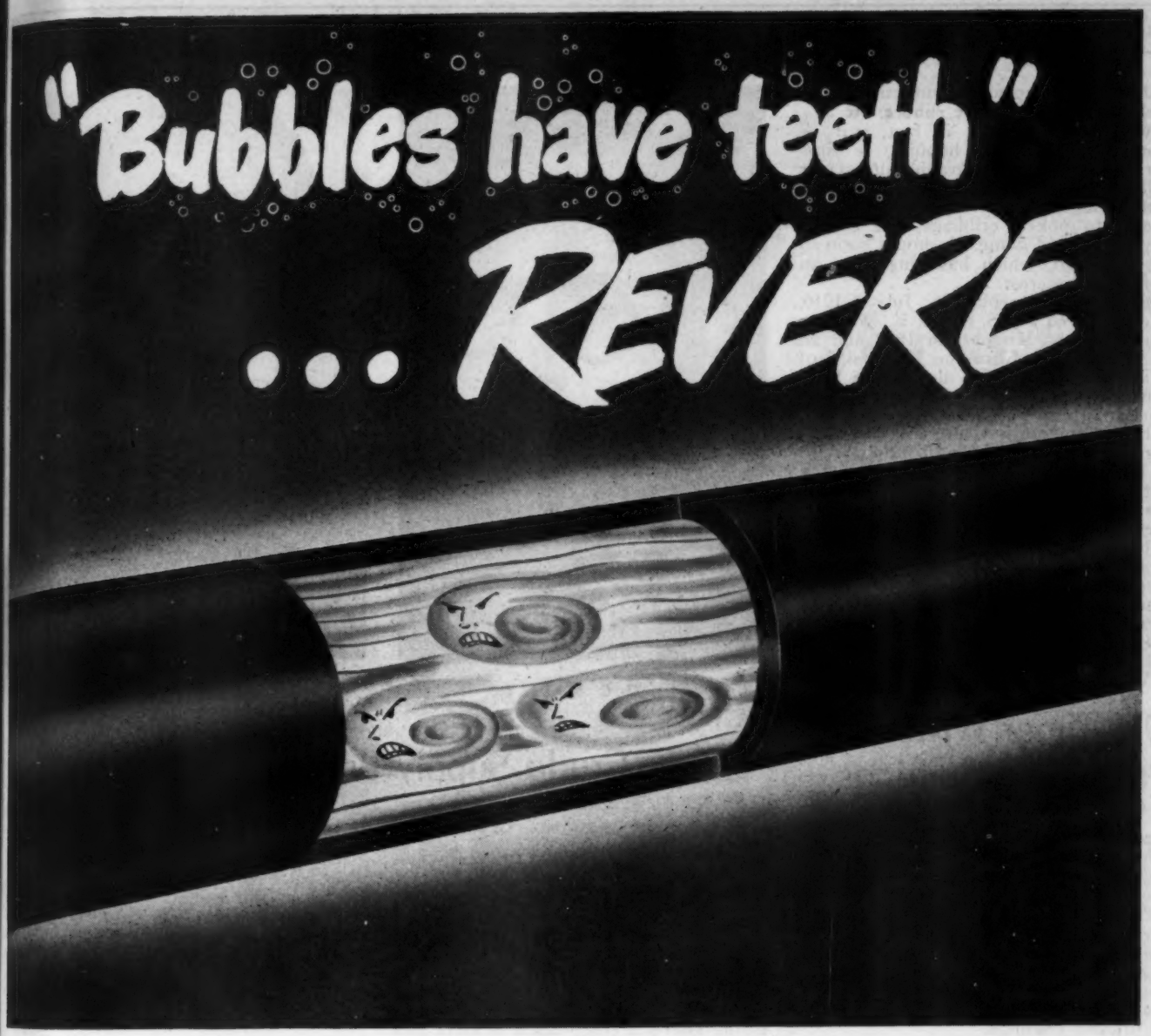
Weil has written nearly 100 technical, economic, and popular articles on chem-

■ CONTINUED ON PAGE 152

Instrument Work is UOP Man's Subject

THE article, "Instrument Maintenance," which begins on page 111 of this issue of PETROLEUM REFINER was written by H. A. Hulsberg, manager of the instrument department of Universal Oil Products Company, Chicago. Hulsberg graduated from the University of Wisconsin (1932) with a B.S. in electrical engineering.

He worked with Western Electric Company and Temple Radio Corporation, in addition to some work on waterproofing compounds, before joining Universal in 1934. Hulsberg was in charge of the electrical and instrument shop at the UOP Riverside laboratories from 1936 until his recent transfer to the Chicago office recently as manager of the instrument department.



SOME years ago Revere said that "Bubbles have teeth." It is still true. Air bubbles in a condenser can eat away at the tubes quite rapidly, and become a cause of failure with consequent re-tubing. Air-entrainment, as it is called, acts in several ways, all destructive to tubes. Air contains oxygen, which directly attacks most metals, forming oxides. Carbon dioxide in solution dissolves these oxides. That is not all. Air bubbles add to the erosion effect of turbulent flow. The higher the velocity, the worse the effect, and the more swift and serious is the combination of erosion and corrosion at points of greatest disturbance. Every effort should be made therefore to keep air from being carried into the cooling water. If you are troubled by frequent re-tubing of your condenser, get in touch with Revere, but first save a few samples from failed tubes for examination by our laboratories to determine the cause of failure. Many users of condenser tubes have found our collaboration exceedingly valuable, and we are always glad to cooperate in an effort to extend tube life.

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icals from petroleum, synthetic liquid, fuels, plastics, synthetic rubber, etc.

Weil's chief hobby, in fact, is free-lance writing. Other hobbies, as time permits, include photography and stamp collecting. His chief recreation is contract bridge, but he is far from being averse to poker, cribbage and almost any other card game. He hopes soon to take up golf, which has long been an unfulfilled interest.

Born in St. Joseph, Mo., July 8, 1916, Weil received a B.S. in Ch. E. from the University of Missouri in 1939 and an M.S. in Ch. E. from the University of Wisconsin in 1940. He also held a Wisconsin Alumni Research Foundation scholarship at the latter school.

Before coming to Georgia Tech, where his work is concerned with the direction of literature searching, publications, and patents, he was head of the information section of the Gulf Research & Development Company.

He went with Gulf Research in 1940 and five years later shifted to Georgia Tech. He is a member of the American Chemical Society and its Petroleum Chemistry and Industrial and Engineering Chemistry divisions. He is also member of Tau Beta Pi.

Weil is married and has one child.

O. C. BLADE

HAROLD M. SMITH

Sour Crude Supply Bureau Men's Topic

THE authors of "Sour Crude—Trends in Supply," (starts on page 101). Harold M. Smith and O. C. Blade, are United States Bureau of Mines workers, both being stationed at the Experiment Station in Bartlesville, Okla. The article is an adaptation from a paper which was presented to an API Division of Refining Group session on sour-crude processing and is a compilation of facts and figures which answer the question, "where does sour crude come from?"

Smith is a native of Rhode Island who was educated in Massachusetts. Clark College in 1921 awarded him a B.A. degree and a year later an A.M. He majored in chemistry. In 1923 he joined the Bureau of Mines Station at Bartlesville where currently he is principal petroleum chemist in charge of the chemistry and refining section. He is the author and co-author of many publications most of them in the field of the composition and analysis of petroleum and its products.

Blade was graduated from the University of Colorado in 1926 with a B.A. degree, having majored in chemistry. Upon entering civil service, his first work was at the Laramie, Wyo., petroleum field office of the Bureau of Mines. In 1930 he transferred to Bartlesville where he has worked on many problems dealing with the chemistry and refining of petroleum. Many Bureau of Mines reports on these topics bear his by-line.

Old Timer Writes on Protective Coatings

C. R. E. MERKLE is an old hand when it comes to this business of protective coatings, and with a record of more than 43 years devoted to the technical development and manufacture, there is no denying his knowledge and ability. He introduced the use of oxidation inhibitors in this field and his broad experience has aided in the solution of many problems concerned with the use of organic coatings.

His article, "The Protection and Maintenance of Petroleum Property," beginning on page 134 of this month's issue of PETROLEUM REFINER, is of special interest to those in the industry concerned with protective coatings. And they, it may be added, are legion.

C. R. E. MERKLE

Merkle is manager of technical sales development in the chemical division of E. I. du Pont de Nemours & Company, Wilmington, Del., which provides ample opportunity to indulge in an acknowledged inherent desire "to help the other fellow," which also explains one of the reasons for writing the current article.

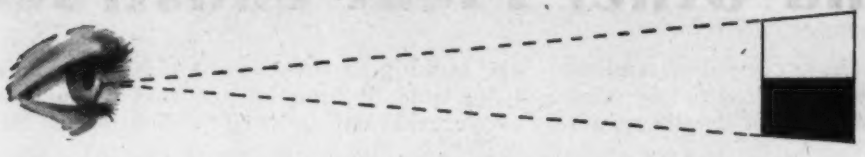
Merkle lays claim to no well-defined hobbies, just a deep interest in the problems of the protective coating industry. He's the sort who likes to help the other fellow; in fact, that's why this article came to be written. Relaxation is provided by his gardening and bridge playing, and during the summer he likes swimming and fishing at his summer home on the seashore.

Socony-Vacuum Picks Holton as Chairman

After 41 years with Socony-Vacuum Oil Company, Inc. Harold F. Sheets, chairman of its board, has retired. George V. Holton has been elected to succeed Sheets as chairman of the board.

Sheets started as assistant to the managing director of Vocuum Oil Company's subsidiary in Germany. Later he became president of Vacuum's affiliated companies in France, Spain, Belgium and Italy. Sheets returned to New York in 1924 and in 1930 was elected a director. He has been chairman of the board since 1944.

Holton has been a vice president since 1938 and is general counsel of Socony-Vacuum.



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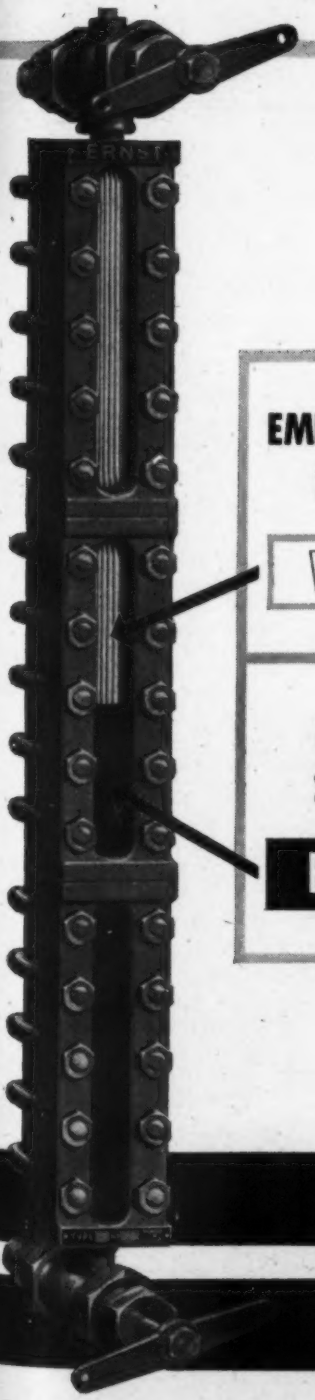

There can be no mistake in reading the Penberthy Reflex Gage. Due to the optical effect of the prismatically grooved glass, the liquid always shows black, and the empty space white. This optical effect is unvarying and absolutely sure. As a result, you can read the gage correctly as far as you can distinguish black and white . . . read it at a glance. There is no squinting to see the meniscus . . . the dividing line between liquid and empty space is always sharp and unmistakable.

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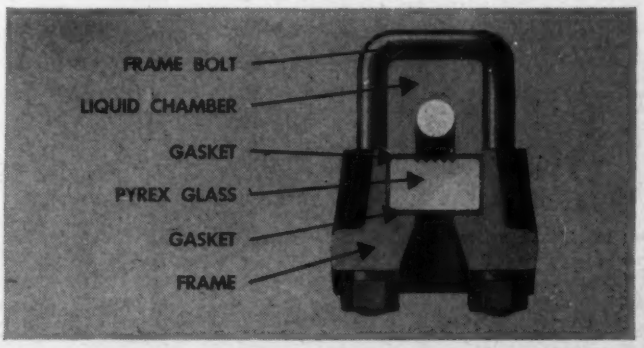

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PENBERTHY Reflex

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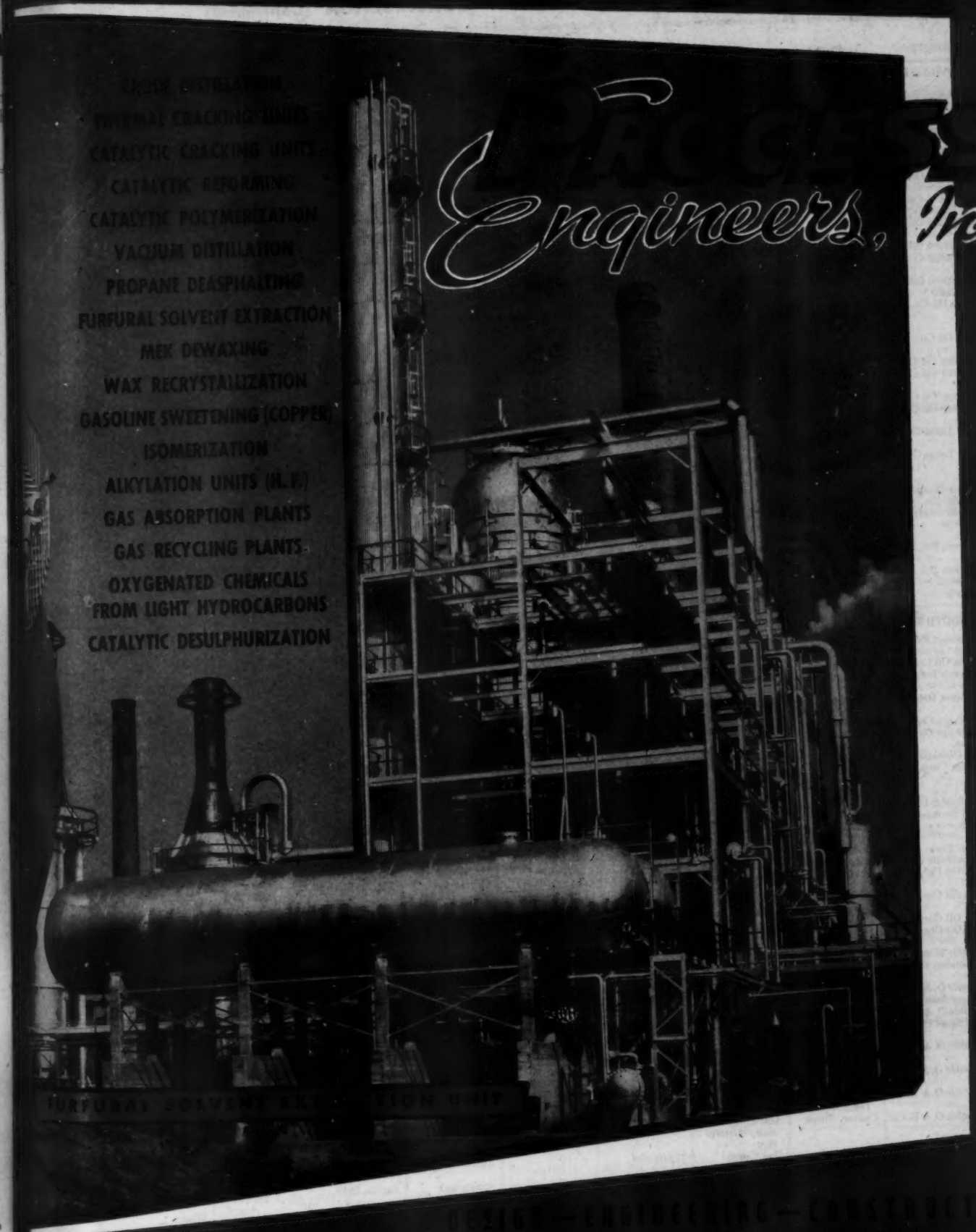
Refinery and Other Plant Construction

Companies whose projects are not listed or readers who know of unlisted projects are urged to: 1) send in data on units not listed; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil Co.	Linden, New Jersey	Vac. pipe still	49,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D. & Braun	Braun
Esso Standard Oil Co.	Linden, New Jersey	Cat. Crack, Light Ends	41,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D., Braun	Braun
Gulf Oil Corp.....	Philadelphia, Pa.	Naptha, Polyform	16,000 bbls. (circ.)	.....	Under Constr.	.....	Gulf-Phillips	Lummus	Lummus
Gulf Oil Corp.....	Philadelphia, Pa.	Vacuum Unit	12,000 bbls.	.....	Under Constr.	.....	.....	Lummus	Lummus
*Kendall Ref. Co..	Bradford, Pa.	De-ethanizing Tower	50 bbls.	$15,000	Material on Order	Sept. 1948	.....	.....	.....
*The Pennsoil Co...	Rouseville, Pa..	Boiler House add.	.....	.....	Contracted	Late 1948	.....	Dravo Corp.	Union Iron Wks. and Dravo
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Lube Plant	.....	Part of $45 million	Under Constr.	Jan. 1, 1949	Texaco	Badger	Badger
*L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant, Anti-Pollution	.....	$400,000	Approved	1948-49	.....	Chenical Comst. Co.	Morris Knowles & Co.
Sun Oil Co.....	Marcus Hook, Pa.	Lube, Wax, Anti-Pollution Project	.....	.....	.....	.....	.....	.....	.....
The Texas Co.....	Eagle Pt., New Jersey	Vac. still, Cat Cracking	40,000 bbls.	.....	Contract let	Late '49	.....	Kellogg, Texaco Co.	Kellogg, Foster-Wheeler
MID-CONTINENT									
Aetna Oil Co.....	Louisville, Ky.	Gasoline Recovery Unit	800 mcf	$75,000	Under Constr.	.....	.....	Aetna	Aetna
Bareco Oil Co.....	Wichita, Kans.	Cat. desul. Reforming	4,000 bbls.	$500,000	Under Constr.	June, '48	Phillips	Koch Eng. Co..	Koch Eng.
*Bay Petroleum Co.	McPherson, Kas.	Thermal Reformer Unit	.....	$145,000	Contracted	.....	.....	.....	Ref. Eng. Co.
Berry Asphalt Co...	Waterloo, Ark.	Lub Unit, Expand Asphalt facilities	1,200 bbls.	.....	Under Constr.	Mid '48	.....	.....	.....
Berry Asphalt Co..	Stephens, Ark.	Expand Asphalt Facilities	2,000 bbls.	.....	Under Constr.	Mid '48	.....	.....	.....
Cities Service Oil Co.	Chicago	Compounding & Grease Plant	1,500 bbls.	$2.5 million	Design	Early '49	.....	Sumner-Sollitt	.....
Cities Service Oil Co. (Delaware)	E. Chicago, Ill	Modernize plant	.....	$18 million	Under Constr.	Late '48	Kellogg	Kellogg	Kellogg
Cities Service Oil Co. (Delaware)	E. Chicago, Ill	Laboratory	.....	$300,000	Under Constr.	July, '48	.....	Cities Service	Sumner-Sollitt
Consumer Co-operative Association	Coffeyville, Kansas	MEK Dewaxing	2500 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
Fen-Ter Refg. Co...	Wynnewood, Okla.	Enlarge Asphalt Plant	8000 bbls.	$250,000	Under Constr.	July, 1948	.....	Ref. Eng. Co.	Ref. Eng. Co.
*Fen-Ter Ref. Co...	Wynnewood, Okla.	Asphalt Specialties Llant			Under Constr.	July, 1948	.....	Ref. Eng. Co.	Ref. Eng. Co.
Gulf Rfg. Co.....	Toledo, O.	Top & Vac. Unit	32,000 bbls.	.....	Under Constr.	Oct., 1948	.....	Badger	Badger
Gulf Rfg. Co.....	Toledo, O.	Fluid Cat. Crk.	15,500 bbls.	.....	Under Constr.	May, 1949	.....	.....	Kellogg
Gulf Rfg. Co.....	Toledo, O.	Polyform Unit	5,000 bbls.	.....	Under Constr.	May, 1949	U.O.P.	.....	Kellogg
Gulf Ref. Co.....	Cincinnati	Fluid Unit	15,500 bbls.	.....	Under Constr.	June, 1949	.....	.....	Kellogg
Gulf Rfg. Co.....	Cincinnati	Polyform Plant	5,000 bbls.	.....	Under Constr.	June, 1949	U.O.P.	.....	Kellogg
Otha A. Grimes....	Holdenville, Okla.	Gasoline Plant	400,000 mcf	$1,350,000	.....	.....	.....	.....	.....
Hagy, Harrington & Marsh	Hooker, Okla.	Gasoline and LPG Recovery	100,000 mcf	$2 million	Under Constr.	July 1, '48	.....	Pritchard	Pritchard
Hiwan Oil Co.....	Magnolia, Ark.	Gasoline Plant	10,000 mcf	.....	First Stage Completed	.....	.....	Petro. Eng.	Petro. Eng.
*Indiana Farm Bureau Co-op. Assn., Inc.	Mt. Vernon, Ind.	Enlarge Topping Unit	7,000 bbls.	.....	.....	Sept., 1948	.....	.....	Own Staff
Kanotex Refg. Co	Arkansas City, Kans.	Cat Cracking	4,200 bbls.	$500,000	Contract let	Early '48	Phillips	Koch Eng.	Koch Eng.
Mid-Continent Pet. Co.	Tulsa, Okla.	Vac still, Cat Cracking	45,000 bbls.	$8.5 million	Contract let	June, '48	Kellogg	Kellogg	Kellogg
Midland Cooperative Wholesale Co.	Cushing, Okla.	Thermal Reforming	1,400 bbls.	Part of $500,000	Under Constr.	Aug., 1948	U.O.P.	U.O.P. and Ref. Eng. Co.	Ref. Eng. Co.
Midland Cooperative Wholesale Co.	Cushing, Okla.	Increase Topping Capacity	6,500 bbls.	Part of $500,000	Under Constr.	Aug., 1948	U.O.P.	U.O.P. and Ref. Eng. Co.	Ref. Eng. Co.
Ohio Oil Co.....	Robinson, Ill....	Vac Unit, Cat crack, Crude Still, Poly, L P G Recovery	27,500 bbls.	$15 million	Under Constr.	Late '48	U.O.P.	McKee	McKee, Pritchard
Old Dutch Ref. Co..	Muskegon, Mich.	LPG Recovery	3,400 gallons	$45,000	.....	.....	U.O.P.	Old Dutch	Old Dutch
*Old Dutch Ref. Co.	Muskegon, Mich.	Crack Plant Revamp	800 bbls.	$30,000	Under Constr.	July, 1948	U.O.P.	Own Staff	Own Staff
Peteo Corporation..	Blue Island, Ill.	Skim. & Crkg.	10,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
Phillips Pet. Co....	Kansas City, Kansas	Cat Cracking, Poly and Vacuum Units	.....	.....	Contracted	.....	.....	Braun	Braun
Rock Island Rfg. Corp.	Rock Island, Ind.	Fluid Cat, Crack.	10,000 bbls.	$1,200,000	Contracted	Early '49	U.O.P.	U.O.P.	Own Staff
Root Pet. Co.....	El Dorado, Ark.	Revision of Cat. Cracker	7,000 bbls.	$125,000	Under Constr.	May, 1948	.....	U.O.P.	Mason Bros.
Sinclair Refg. Co...	East Chicago, Ill.	Crude, Cat. Cracker, Poly Plant & Lube Treating	55,000 bbls.	.....	Under Constr.	Late, '48	.....	Lummus, Braun, Sinclair	Braun, Lummus
*Skelly Oil Co.....	El Dorado, Kas.	Crude Distl. Unit, Cat. Crack	30,000 bbls.	.....	Announced	Jan., 1950	.....	.....	.....
Skelly Oil Co.....	Stephens Co., Okla.	Gasoline plant	.....	.....	.....	.....	.....	.....	Born
Socony-Vacuum Oil Co., Inc.	E. St. Louis, Ill.	Thermal Cracker & distillation	.....	Part of $45 million	Contract let	Jan. 1, 1949	.....	Bechtel Corp.	Bechtel Corp.
Socony-Vacuum Oil Co., Inc.	Augusta, Kans.	Cat Cracking	10,000 bbls.	Part of $45 million	Projected	.....	.....	.....	.....

TABLE CONTINUED ON PAGE 156


Engineers, Inc.
CRUDE DISTILLATION
THERMAL CRACKING UNITS
CATALYTIC CRACKING UNITS
CATALYTIC REFORMING
CATALYTIC POLYMERIZATION
VACUUM DISTILLATION
PROPANE DEASPHALTING
FURFURAL SOLVENT EXTRACTION
MEK DEWAXING
WAX RECRYSTALLIZATION
GASOLINE SWEETENING (COPPER)
ISOMERIZATION
ALKYLATION UNITS (H.F.)
GAS ABSORPTION PLANTS
GAS RECYCLING PLANTS
OXYGENATED CHEMICALS
FROM LIGHT HYDROCARBONS
CATALYTIC DESULPHURIZATION

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Stanolind O & G Co.	Hugoton Field, Kansas	Gasoline Plant	150,000 mcf	.....	Approved	.....	.....	J & L Constr.	J & L Constr.
Stanolind O & G Co.	Garden City, Kas.	Gas Syn. Plant	100,000 mcf	$80 million	Constr. in Fall, '48	Jan., 1950	.....	Hydro Research	Kellogg, Foster-Wheeler, Stone & Webster
Stanolind O & G Co.	Garden City, Kans.	Chemical Plant	130,000 lbs./yr.	.....	Announced	.....	.....	Badger	Badger
Stanolind Oil & Gas Co.	Ulysses, Kan.	Gasoline Plant	100,000 mcf.	.....	Under Constr.	Fall, '48	.....	.....	.....
Standard Oil Co. (Indiana)	Casper, Wyo.	Cat Crack.	8,000 bbls.	.....	Under Constr.	Early 1949	.....	.....	Kellogg
Standard Oil Co. (Indiana)	Sugar Creek, Missouri	Cat Cracking	25,000 bbls.	.....	.....	Spring '48	.....	.....	Kellogg
Standard Oil Co. (Indiana)	Whiting, Indiana	Cat Cracking	25,000 bbls.	.....	Under Constr.	Spring '48	.....	Lummus S.O.D. & Braun	Kellogg
Standard Oil Co. (Indiana)	Whiting, Ind.	Motor Oils Unit	.....	.....	Under Constr.	Mid 1948	.....	.....	Foster-Wheeler, Stone & Webster Kellogg
Standard Oil Co. (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$10 million	Contract let	Late '49	U.O.P.	McKee	McKee
*Sun Oil Co.	Toledo, Ohio	Cat. Crack, Crude Distil., Vac., Poly.	30,000 bbls.	$16 million	Announced	1950	.....	.....	.....
Sun Oil Co.	Toledo, Ohio	Anti-Pollution Project	.....	$600,000	.....	.....	.....	.....	.....
Sunray Oil Co.	Duncan, Okla.	Crude Plant	20,000 bbls.	.....	Under Constr.	April, 1948	.....	U.O.P.	Ref. Eng. Co.
Sunray Oil Corp.	Duncan, Okla.	Cat. Poly.	1000 bbls.	$271,000	Under Constr.	May, 1948	U.O.P.	U.O.P. and Ref. Eng. Co.	Ref. Eng. Co.
Sunray Oil Corp.	Duncan, Okla.	2 Treating Units	.....	.....	Under Constr.	.....	U.O.P.	Ref. Eng. Co.	Ref. Eng. Co.
Sunray Oil Corp.	Duncan, Okla.	Revision Cat. Cracker	10,000 bbls.	$150,000	Under Constr.	May, 1948	U.O.P.	U.O.P.	Mason Bros.
The Texas Co.	Lawrenceville, Illinois	Crude and Cat Cracking	20,000 bbls.	.....	Site being Cleared.	1950	.....	Foster-Wheeler	Kellogg, Foster-Wheeler
The Texas Co.	W. Tulsa, Okla.	Crude and Cat Cracking	30,000 bbls.	.....	Contract let	1949	.....	Texas Co., Kellogg, Foster-Wheeler	Kellogg, Foster-Wheeler
Trans-Marine O. Rfg. Co.	S. Milwaukee, Wis.	Crude, Vac., Refrm, Desulf.	5,000 bbls.	$1.3 million	Under Constr.	.....	.....	.....	Ref. Eng. Co.
*U. S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	80 bbls.	$4.4 million	Contracted	Oct. 1949	.....	Koppers	Koppers
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	1,500 bbls.	.....	Projected	Jan. 1, 1949	.....	Hudson	Hudson
Warren Pet. Corp.	Maysville, Okla.	Gasoline Plant	8,000 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Illinois	Cat Cracking, gasoil, Cracking	8,500 bbls.	$1 million	Under Constr.	Late '48	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
American Republics Corp.	Silsbee, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	Gasoline Plant Constr. Co.
Arkla Oil Co.	Rodessa, La.	Add Compressors	60,000 mcf	$325,000	.....	.....	.....	.....	Own Staff
*Bryson Refg. Co.	Bryson, Texas	Run Down Tanks	2,000 bbls.	$3000.	.....	.....	.....	.....	.....
Calumet Refg. Co.	Princeton, La.	Modernization of Lube Plant	700 bbls.	.....	Under Constr.	Early '49	.....	.....	.....
Carthage Corp.	Carthage, Field	Gasoline Plant	100,000 mcf	$3.5 million	Under Constr.	Jan. 1, '49	.....	Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Tex.	Hydrocol	64,000 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc., Texaco	McKee	McKee
The Chicago Corp.	Carthage, Tex.	Enlarge Gas. Plt.	210,000 mcf	$2 million	Authorized	June, 1949	.....	Own Staff	.....
Citcon Corp.[1]	L. Charles, La.	Lube Plant	6,000 bbls.	$30 million	Under Constr.	.....	Texaco, Max B. Miller	Max B. Miller Lummus Citcon	Lummus, Max B. Miller
Continental Oil Co.	Sonora, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	Brown & Root
Esso Standard Oil Co.	Baton Rouge, Louisiana	Lub. Vac. still, Crude, Dewax, poly.	111,500 bbls.	.....	Under Constr.	Early '48	Texaco	Badger, S.O.D., Braun, McKee, Kellogg	Badger, Kellogg, McKee, Braun
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$20 million	Announcement	.....	.....	.....	.....
Gray-Wolfe Co.	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	Jan., 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D Bowden
Gulf Oil Corp.	Pt. Arthur, Tex.	3 Top. & Vac. units	22,000 bbls. ea.	.....	Under Constr.	April-June, 1948	.....	.....	Badger
Gulf Oil Corp.	Pt. Arthur, Tex.	Cat. desulf.	17,000 bbls.	.....	Under Constr.	.....	.....	Lummus	Lummus
Gulf Oil Corp.	Pt. Arthur, Tex.	Naphtha Polyform.	32,000 bbls. circ.	.....	Under Constr.	.....	.....	Lummus	Lummus
Humble O. & R. Co., (London Plant)	Overton, Texas	Add Propane Absorption Refrigeration	Gas	.....	Under Constr.	June, 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co., (American Plant)	Overton, Texas	Add Propane, Absorption	Capacity	$2 milliom	Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co., (Kilgore Plant)	Laird Hill, Texas	Add Propane, Absorption—Refrigeration	Unchanged		Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.	Katy, Texas	Add Propane, Absorption	.....	$7 million	Under Constr.	March, 1949	.....	Stearns-Roger	Stearns-Roger
*Humble O. & R. Co.	Kelsey Field, Texas	Gas Injection, Plant	18,000 mcf	.....	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
*Humble O. & R. Co.	Seeligson Field, Texas	Gas Injection Plant	20,000 mcf	.....	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
*Humble O. & R. Co.	Conroe, Texas	Add Compression—Absorption	30,000 mcf	.....	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
*Humble O. & R. Co.	Bloomington, Texas	Gas Comp. Plant	22,000 mcf	.....	Authorized	1949	.....	.....	.....
*Humble O. & R. Co.	Opelousas, La.	Absorption Plant	100,000 mcf	.....	Authorized	Spring, 1949	.....	.....	.....
*Humble O. & R. Co.	Pickton Field, Texas	Comp—Absorp. Plant	18,000 mcf	.....	Authorized	Spring, 1949	.....	Fluor	Fluor
Humble O. & R. Co.	Baytown, Texas	Lube dewaxing	4,600 bbls.	$6 million	Under Constr.	Early '48	Texaco	Badger	Badger
*Hutex O. & Refg. Co.	Hardin, Texas	New Crude Furnace	500 bbls.	$3,000.	Under Constr.	May, 1948	.....	Staff	Staff
Jefferson Chem. Co.	Pt. Neches, Tex.	Petro-chem	.....	.....	Essentially Completed	.....	.....	Jefferson	Jefferson, Badger, Lummus
Magnolia Pet. Co.	Beaumont, Tex.	Lube Plant	.....	.....	Under Constr.	Jan. 1, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline Plant	90,000 mcf	.....	.....	Late '48	.....	Hudson	.....
Magnolia Pet. Co.	Mamou, La.	Gasoline Plant	7,000 mcf	.....	Under Constr.	Late '48	.....	.....	Gaso. Plant
Fred M. Manning, Inc.	Stephens Co., Texas	Pressure Maintenance	20,000 mcf	$500,000	Contract let	Completed, testing	.....	Fish Eng. Corp.	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
McCarthy Chem. Co.	Winnie, Texas	Petro-chem, Cat Cracking	5,000 bbls.	$3 million	Under Constr.	.....	Phillips	Fish Eng. Corp.	.....
Monsanto Chem. Co.	Texas City, Tex.	Rebuilding Petro-chem	.....	$6 million	Contract let	.....	.....	.....	Bellows Co., Leon Cen. Co.
Peteo Corporation	Marrero, La.	Skim. & Crkg.	5,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
Phillips Pet. Co.	Hansford Co., Texas	Gasoline & LPG Plant	343,000 mcf	.....	Announced	.....	.....	Own Staff	.....
Plomo Co.	Agua Dulce Feld	Processing Plant	30,000 mcf	$1 million	Under Constr.	"Soon"	.....	.....	.....
Pure Oil Co.	Smith's Bluff, Texas	Lube Plant	.....	$9 million	Under Constr.	July, 1949	Texaco	Lummus	Lummus
Republic O. Refg. Co.	Texas City, Texas	Recondition Cat. Cracker	.....	$750,000	Under way	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason Bros.
Republic O. Refg. Co.	Texas City, Texas	Poly Plant	.....	.....	Under Constr.	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason Bros.
Richardson and Bass	Keystone Field, Texas	Gasoline Plant	70,000 mcf	.....	Constr. Appr'vd	10-1-48	.....	J & L Constr.	J & L Constr.
Shell Chemical Corp.	Houston, Texas	Glycerine	.....	Part $35 mln.	Under Constr.	Early '48	.....	.....	Braun
Shell Oil Co.	Notrees, Texas	Gasoline Plant	45,000 mcf	$4 million	Under Constr.	Early '48	.....	Brown & Root	Brown & Root
Shell Oil Co.	Houston, Texas	Lube Unit	2,800 bbls.	$10 million	Under Constr.	July '48	Texaco	Lummus	Lummus, Kellogg, Fluor
Shell Oil Co.	Denver City, Tex.	Gasoline Plant	24,000 mcf	.....	Under Constr.	1948	.....	.....	Fluor Corp.
Shell Oil Co.	Norco, La.	Thermal Cracking, Asphalt Plt.	12,000 bbls.	.....	.....	Early '48	.....	Shell	Shell
Sid Richardson Carbon Co.	Odessa, Texas	Carbon black Plant	194,500 lbs.	.....	Under Constr.	.....	.....	.....	.....
Sid Richardson Gasoline Co	Kermit, Texas	Gasoline & LPG Plant	200,000 gallons	.....	.....	.....	.....	.....	.....
Sinclair Refg. Co.	Houston, Texas	Crude Still, Barrel House, Grease Works.	30,000 bbls.	.....	Under Constr.	.....	.....	.....	Fluor
Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	Under Constr.	August, '48	.....	Process Eng.	Process Eng.
Stanolind O & G Co.	Slaughter, Texas	Gasoline Plant	90,000 mcf	.....	Under Constr.	Dec., 1948	.....	Braun	Braun
Stanolind O & G Co.	Hockley County, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	.....
Stanolind O & G Co.	Brownsville, Tex.	Chemical Plant	130,000 lbs./yr.	.....	Announced	.....	.....	Badger	Badger
Stanolind O & G Co.	Pettus, Texas	Cycling Plant	159,000 mcf	.....	Projected	1949	.....	J & L Constr.	J & L Constr.
Sun Oil Co.	Richland Parish, Louisiana	Gasoline Plant	70,000 gal.	.....	Under Constr.	May, '48	.....	.....	Pet. Eng., Inc.
Sun Oil Co.	Starr Co., Tex.	Gasoline Plant	25,000 mcf	Part of $12 mil.	Bids asked	April, 1949	.....	.....	.....
Talco Asphalt & Refining Division American Liberty Oil Co.	Mt. Pleasant, Texas	Poly L.P.G. Plant	26,800 mcf	$225,000	Under Constr.	Early, '48	U.O.P.	Talco	Talco
*The Parade Co.	Rusk County, Texas	Add. Propane Recovery	18,000 mcf	$250,000	Contracted	Dec., 1948	.....	Hudson	Hudson
The Texas Co.	Port Arthur, Texas	Lube & Wax additions	2.500 bbls. oil	.....	Under Constr.	Late '48	.....	Texas Co., Foster-Wheeler	Foster-Wheeler
The Texas Co.	Lafitte, La.	Expand Gaso-Plant	6,500 mcf	.....	.....	.....	.....	Hudson	Hudson
United Gas Co.	Carthage, Tex.	2nd Gas. Plant	100,000 mcf	$3.5 million	Announced	Feb., 1949	.....	Hudson	Hudson
Waggoner Est. Ref.	Electra, Tex.	Crack Unit Revisions	.....	$250,000	Under Constr.	Fall, 1948	.....	Ref. Eng. Co.	Ref. Eng. Co.
Warren Pet. Corp.	Breckenridge, Texas	L.P.G. Extraction	1,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Warren
*Warren Pet. Corp.	Hawkins, Texas	Plant Enlargement	20,000 mcf	.....	Contract let	March, 1949	.....	Gaso. Plant	Gasol. Plant.
Warren Pet. Corp.	Holliday, Tex.	Expansion & Propane prod.	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Warren
*Warren Pet. Corp.	Taylor's Corner, Texas	Gasoline Plant	5,000 mcf	.....	Contract let	March, 1949	.....	Waleo	Waleo
Winnsboro Refg. Co.	Winnsboro, Tex.	Crude Plant	3,000 bbls.	$175,000	Under Constr.	Early '48	.....	.....	Mid-Continent
Witco Hydrocarbon Corp.	Big Lake, Texas	Gasoline Plant	2,500 bbls.	$2.6 million	Under Constr.	July '48	.....	Witco	Fish
Witco Hydrocarbon Corp.	Witco, Texas	Carbon Black	.....	Part of $3.5 million	Contracted	.....	.....	Fish	Fish & Witco
ROCKY MOUNTAIN									
The California Oil Company	Rangely, Colo.	Gasoline Plant	25,000 gals.	$3 million	Under Constr.	'48	.....	Hudson	Hudson
Carter Oil Co.	Billings, Mont.	Crude Cat Crk.	30,000 bbls.	$20 million	Under Constr.	3rd Qtr. 1949	.....	U.O.P., S.O.D.	Fluor Corp.
Continental Oil Co.	Billings, Mont.	Cat Cracking	7,500 bbls.	$8.5 million	Contract signed	1949	U.O.P.	U.O.P.	J & L Constr.
Continental Oil Co.	Denver, Colo.	Crude, Cat Crk.	7,500 bbls.	$4 million	Under Constr.	Fall 1948	Houdry Corp. & U.O.P.	Con. Oil Co., Lummus	Lummus
Gulf Oil Corp.	Eunice, N. M.	Gasoline Plant	.....	.....	.....	.....	.....	Hudson	Hudson
Salt Lake Ref. Co.	Salt Lake City	Crude Dist. Unit	25,000 bbls.	$5 million	Under Constr.	Nov. 1948	.....	.....	Bechtel
Shelly Oil Co.	Lea County, N. M.	Expanding Gasoline plant	.....	.....	.....	.....	.....	.....	J. E. Carlson
Socony-Vacuum Oil Co., Inc.	Casper, Wyo.	Cat Cracking	4,000 bbls.	Part of $45 million	Under Constr.	Jan. 1, 1949	.....	Cat. Constr.	Cat. Constr.
Stanolind O & G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Approved	.....	.....	Stone & Webster	Stone & Webster
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	3000 bbls.	$450,000	Under Constr.	Fall, 1948	.....	Ref. Eng. Co.	Ref Eng. Co.
Utah Oil Refg. Co.	Salt Lake City, Utah	Expand existing Refinery	25,000 bbls.	$2.5 million	Announced	Late '48	.....	.....	.....
Warren Pet. Corp.	Monument, N.M.	Gasoline Plant Enlargement	2,500 bbls.	.....	Under Constr.	Jan 1, 1949	.....	Warren	Dresser Eng.
WEST COAST									
General Pet. Corp.	Torrance, Calif.	Vacuum flash tower	32,000 bbls.	$558,000	Contracted	3rd Qtr. '48	.....	Braun	Braun
Hancock Chem. Co.	Watson, Calif.	Elemental Sulfur Plant	50 tons	$1 million	Engineering being completed	Nov., 1948	.....	Badger	Badger
Shell Chemical Co.	Martinez, Calif.	Pet. Additives Plant	.....	.....	Under Constr.	Late 1948	.....	Parsons	Parsons
Robt. S. Lytle, Opr.	Coalinga, Calif.	H_2S Removal Plant	33,000 mcf	$175,000	Engineering in Course	1 year	Fluor	Fluor	Fluor
Shell Chemical Corp.	Shell Pt. Calif.	Syn. Ammonia	.....	.....	.....	Early '48	.....	.....	.....
Standard Oil Co., of Calif.	Bakersfield, Calif.	Crude dist, Cat Cracking	10,000 bbls.	$7.5 million	Announced	Mid '49	Braun	Braun	Braun
Standard Oil of Calif.	Bakersfield, Calif.	Thermal Crk., Gaso. Stabil., Gaso. Treating	9,000 bbls.	.....	Contracted	.....	U.O.P	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Filling Plant Modernization	.....	$2 million	Under Constr.	Dec. '48	.....	.....	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Standard Oil Co. of Calif.	Richmond, (California)	Grease, Wax Plant, Dock Facilities	82,000 lbs.	$13 million	Under Constr.	Sept. '48	U.O.P.	W. G. Peugh	Barrett & Hilp, Swinerton & Walberg & Ben C. Gerwick Inc., Humiston-Rosendahl Inc.
FOREIGN									
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
*Anglo-Iranian Oil Co.	Abadan, Persian Gulf	Cat. Cracker	30,000 bbls.	.....	Planned	.....	.....	.....	.....
*Anglo-Iranian Oil Co.	Abadan, Persian Gulf	Lube Plant	400 bbls.	.....	Planned	.....	.....	.....	.....
*Bahrein Pet. Co., Ltd.	Bahrein Island	Expansion Program	.....	$8.9 million	Under Constr.	June, 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
British Pet. Chem., Ltd.	Grangemouth, Scotland	Petro-chem	.....	$20 milliom	Planned	.....	.....	.....	.....
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Crude Plant	20,000 bbls.	$18 million	Projected	Early '50	.....	McKee	McKee
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Under Constr.	By 1950	Lummus, Kellogg	Lummus	Badger.
*Consolidated Refineries, Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
Creole Pet. Corp.	Amuay Bay, Venezuela	Cat Cracking	60.000 bbls.	$70 million	Under Constr.	1950	.....	.....	.....
Creole Pet Corp.[2]	Molata Field, Venezuela	Stabilisation and Repressuring Plants	.....	.....	.....	.....	.....	.....	.....
Creole Pet. Corp.[3]	El Roble Field, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Egyptian Government	Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Imperial Oil, Ltd.	Montreal, East, Canada	Crude Pipe, Still, Cat Cracker, Cat Poly	33,000 bbls.	$22 million	Under Constr.	Summer '48	.....	S.O.D., Kellogg	Kellogg
Imperial Oil Ltd.	Edmonton, Canada	Thermal Crack, Crude Dist.	6,000 bbls.	$7 million	Under Constr.	1948	.....	Barnes, Impl. Oil	Barnes
Imperial Oil, Ltd.	Leduc field	Gas absorption Plant	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantau, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
*McColl-Frontenac Oil Co., Ltd.	Montreal East Que., Canada	Fluid Cat. & Cat. Poly.	40,000 bbls.	.....	Under Constr.	Mid 1948	.....	Kellogg	Kellogg
Mene Grande	West Guara, Venesuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
*National Oil Refineries, Ltd.	Llandarcy, Wales	Crude & Reform.	20,000 bbls.	$36 million	Planned	.....	.....	.....	.....
*National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.		Planned	.....	.....	.....	.....
Petro Carbon, Ltd.	Partington, Eng.	Cat Cracker, Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd.	Partington, Eng.	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petroleos Mexicanos	Cindad Madero	Crude unit	25,000 bbls.	$2 million	Under Constr.	July, 1948	None	Own Staff	Own Staff
Petroleos Mexicanos	Salamanca, Mex.	Crude, gasoil Cracking	30,000 bbls.	$12 million	Contract let	1949	U.O.P.	McKee	McKee
Porto Marghera Rfg.	Venice, Italy	Enlarging	.....	.....	.....	.....	.....	.....	.....
*Raffineries de Petrole de la Gironde	Ambes, France	Crude Plant	14,000 bbls.	$7.5 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
*Scotish Oils, Ltd.	Grangemouth, Scotland	Crude	24,000 bbls.	$28 million	Planned	.....	.....	.....	.....
*Scotish Oils, Ltd.	Grangemouth, Scotland	Cat Crak.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chemical Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chemical Corp	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co (Venesuela)	Cardon, Venesuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Early '48	.....	.....	.....
*Societe General des Huiles de Petrole	Dunkirk, France.	Crude Reform.	26,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
*Societe General des Huiles de Petrole	Courchelettes, France	Lube & Wax	800 bbls.	.....	Under Constr.	.....	.....	.....	.....
Standard Oil Co. of B.C., Ltd.	Vancouver, B.C.	Asphalt Plant	600 tons	$500,000	Under Constr.	May, 1948	.....	Ralph M. Parsons	Own Staff.
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
*Venesuelan Pet. Co. (Sinclair)	Puerto la Cruz, Ven.	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.	.....	.....	.....	.....	Foster-Wheeler	Foster-Wheeler
Yacimientos Petroliferos Fiscales, Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1949	.....	Foster-Wheeler	Foster-Wheeler
YPF Brasil	Santos, Brasil	Complete Refg.	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....

NOTE—Atlantic—The Atlantic Refining Co. Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Bros., McCone Co. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Clark's—Clark's Construction and Engineering Company. Dresser—Dresser Engineering Corporation. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corporation. Gaso. Plants—Gasoline Plant Construction Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. Hydro Res.—Hydrocarbon Research, Inc. Jefferson—Jefferson Chemical Co. J & L Constr.—Jones and Laughlin Construction Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Company, Inc. Leon Constr.—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Company. McKee—Arthur G. McKee Co. Old Dutch—Old Dutch Refining Company. Parsons—Ralph M. Parsons Co. Phillips—Phillips Petroleum Co. Pet. Eng.—Petroleum Engineers, Inc. Pritchard—J. F. Pritchard & Co. Process Eng.—Process Engineers, Inc. Ref. Eng. Co.—Refinery Engineering Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Texaco—Texaco Development Co. Walco—Walco Engineering Co. Warren—Warren Petroleum Corporation. Westheimer—Westheimer Rigging and Heavy Hauling Company. Wohfeld—Wohfeld Construction Co. [1] Jointly owned by Cities Service Co. and Continental Oil Co. [2] Jointly owned with Pantepec Oil Co. [3] Jointly owned with Pantepec Oil Co. [4] Joint project with Cities Service Oil Co., The Carter Oil Co., Sinclair Prairie Oil Co., with Warren operating plant. [5] Kerr-McGee Oil Industries, Inc., interest. * First appearance in tabulation.

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ACS National Meeting

Thousands attend Chicago sessions. Division of Petroleum Chemistry papers interesting

Approximately 8000 chemists and chemical engineers attended the 113th national meeting of the American Chemical Society in Chicago April 19 through 23.

Advances in food technology which promise relief to the world's hungry millions, progress in the study of plutonium and other new chemical elements discovered on the atomic bomb project, and modern trends in motor fuels were reported.

The quest for new life-saving drugs of the penicillin-streptomycin type, the status of research on the anti-hemorrhagic factor known as vitamin P, and recent developments in plastics, insecticides, rubber, and chemical education were among the other subjects discussed in 800 technical papers at sessions of seventeen professional Divisions of the Society.

Twenty-three chemists and chemical engineers received diplomas certifying continuous membership in the Society for 50 years at a general session, presided over by Dr. Charles Allen Thomas, executive vice president of Monsanto Chemical Company, St. Louis, and president of the ACS. Among those honored was Dr. Frederick Dunlap, 77, of the Wallace & Tiernan Company, Chicago, and Miss Aida M. Doyle, 80, of Miami, Fla., former Washington, D. C., school teacher and government chemist.

"The Effect of the Manhattan Project Work Upon the Development of Analytical Chemistry" was discussed by Professor N. Howell Furman of Princeton University at a dinner of the Division of Analytical and Micro Chemistry.

Speaker from The Hague

Among several foreign speakers at the meeting was Dr. H. Eilers of N. V. De Bataafsche Petroleum Maatschappij, The Hague, who described "The Colloid Structure of Asphalt" before the Colloid Division.

Professor Glenn T. Seaborg of the University of California, co-discoverer of plutonium, presided at a session on the chemistry of the transuranium elements sponsored by the Division of Physical and Inorganic Chemistry.

Dr. Irving Langmuir of the General Electric Company, Schenectady, N. Y., Nobel prize winner and former ACS president, participated in a symposium on aerosols, or smokes and fogs, planned by the Physical and Inorganic Division in cooperation with the Colloid Division.

The need for greater emphasis on scientific research in liberal arts colleges was discussed by representatives of government, industry, and education at a session of the Division of Chemical Education. Design of radiochemistry laboratories, placement of chemists and chemical engineers, and education for professional responsibility were other subjects.

"The Highlights of Present Day Russian Chemical Research" were noted in a paper by J. G. Tolpin of Standard Oil Company (Indiana), Chicago, at an Education Division meeting on general chemical literature.

Sessions held by the Division of Petroleum Chemistry included a meeting where Dr. Gustav Egloff, chairman of the division, and Director of Research of Universal Oil Products Company, Chicago, addressed a symposium on modern motor fuels. Egloff stated that the $9 billion synthetic oil program recently proposed by the government is unnecessary, because there is no real shortage of petroleum, and because the oil industry can meet the present enormous demand for petroleum products. He said that industry is better qualified than the government to develop whatever synthetic fuels may be needed in the future.

Egloff's Remarks

His opposition to government proposals to build plants to produce 2 million barrels a day of oil from coal and shale is based upon his conclusion that the plants would cost $20 to $30 billions instead of the eight or nine estimated by government officials, and he added that the coal requirements would be about 468 million tons per year, or two-thirds of the nation's present production. Moreover, the undertaking would require more than 16 million tons of steel, which "could be used more profitably by the oil industry."

"At present the oft-recurring cry of petroleum shortage is heard," he declared. "This is more apparent than real. Never in the history of the oil industry has there been a real shortage. Not even during the war was a single vehicle held up for lack of gasoline or lubricating oil. Shortages of household heating oil occurred last winter, but these were spot shortages due to lack of transportation facilities.

"The oil industry is thoroughly alert to its responsibilities, and is spending billions each year for exploration, drilling, transportation, and refining projects to meet the growing need for petroleum products. This program includes investigation of the possibilities of synthetic fuel manufacture from natural gas, coal, and shale."

Egloff pointed out that plants designed to turn out a total of 15,000 barrels a day of liquid fuels from natural gas are under construction at Garden City, Kansas, and at Brownsville, Texas.

Pilot plants now operated by the Bureau of Mines, under a $60,000,000 appropriation, to study the production of liquid fuel from coal and shale are providing a fund of information which will be useful in the design of synthetic oil plants, Egloff said, but he voiced opposition to a bill which would allot $400 million to build three commercial units, each with a capacity of 10,000 barrels a day.

"It seems unwise to design and construct these three 10,000-barrel-a-day units until vastly more information is obtained from the Bureau of Mines pilot plants and the oil industry," he contended.

"Not satisfied with this, our government is asking for the construction in the next five or ten years of synthetic oil plants which would produce 2 million barrels of oil a day, somewhat less than 40 percent of our present daily crude oil production.

A Vast Difference

"Government officials estimate that this will cost from $8 to $9 billion dollars. However, based upon the $400 million for three 10,000-barrel-a-day units, the cost of the larger program would be $20 to $26 billion dollars. Oil industry experts estimate the cost at from $20 to $30 billions.

"Another considerable item for such a large-scale development program is the question of technical manpower, and in many cases the establishment of whole communities in the vicinity of the projects. Huge chemical plants for catalyst production would also have to be built.

"The question of synthetic fuel quality is important. While coal gasification and the Fischer-Tropsch process give gasoline of 80 octane number motor method and 93 research method, the coal hydrogenation process produces gasoline of about 75 octane number. Oil shale retorting produces a poor grade of gasoline.

"The economies of fuel production from petroleum versus solid or gaseous fuels should be carefully weighed. The actual cost of the plants for producing 2 million barrels a day of synthetic products is greater than the total investment in all branches of the oil industry.

"In the manufacture of synthetic fuels from coal, more than 60 percent of the potential heat energy is consumed in producing liquid products. At present prices, gasolines from coal and shale are not competitive with those from petroleum.

"It seems wise for our government to stay out of competition with oil and coal companies. It should not be in business competing with private industries operative on incentive lines to produce low cost products. Private industry should not be placed in a position of competing with tax money to which it has contributed substantially."

Abstracts of Papers

A considerable number of worthwhile papers were presented in the technical sessions of the Division of Petroleum Chemistry. Abstracts of the papers judged most interesting to chemists and engineers engaged in oil refining and hydrocarbon processing are given below.

Conversion of Diolefins in Alkylation Feedstocks to Monoolefins by Selective Hydrogenation

JOHN ANDERSON, S. H. McALLISTER, E. L. DERR, and W. H. PETERSON, *Laboratories of Shell Development Company.*

During the critical wartime shortage of light olefins for alkylate gasoline manufacture, means of extending the supply of butylenes and amylenes were sought and possible processes for purification of unsuitable refinery fractions were investigated. Materials contaminated with diolefins were available to some extent, and a vapor-phase process for converting the diolefins in such materials to mono-olefins by selective hydrogenation was devised. The supported

nickel sulfide catalysts employed in the hydrogenation process were found to have a truly remarkable degree of selectivity in that they are active for hydrogenation of diolefins to mono-olefins but relatively inactive for the hydrogenation of mono-olefins to paraffins in the temperature range of 200° to 300° C., even in the presence of a large excess of hydrogen. Butylene and amylene fractions having diolefin contents rendering them unsuitable for isoparaffin alkylation were converted by hydrogenation over NiS catalysts to fractions giving excellent alkylation results. The hydrogenated materials had mono-olefin contents corresponding to the combined concentrations of diolefins and mono-olefins originally present and alkylate yields were improved by amounts depending on the increase in mono-olefins in the feedstocks. Investigation was directed primarily to continuous vapor-phase operation under conditions readily obtainable in existing hydrogenation units of the types used for hydrogenating catalytically cracked gasoline or for converting butylene dimers to isooctanes. The nickel sulfide catalyst employed in most of the work was prepared from a commercially available nickel carbonate-alumina by merely treating with hydrogen sulfide at 400° C. This material proved to have a life of over 1000 hours when treating a C_4 fraction containing 23 mole percent butadiene, and, after losing activity, it was again rendered active by burning and resulfiding.

Hydrocarbons from Petroleum. Composition of the C_6 Fraction of a Catalytic Gasoline by the Distex Process

JOHN GRISWOLD and J. E. WALKEY, *(Richmond, Calif.) The University of Texas, Austin, Texas.*

A hexane-hexene fraction from a Thermofor catalytic gasoline was separated into paraffinic and olefinic portions by the Distex operation. The two portions were analyzed by fractional distillation with refractive indices, aniline points, bromide numbers, and specific dispersions on the small cuts. The percentages of 2,2-dimethylbutane and n-hexane are small, but the ratios of other isomeric hexanes correspond approximately to equilibrium at the cracking temperature. Although a complete analysis as percentage of each individual hexane was not obtainable, many of the known isomers are present.

A Semimicromethod for the Determination of Oil in Petroleum Waxes

J. S. WIBERLEY and J. B. RATHER, JR., *Socony-Vacuum oil Company, Inc., Brooklyn.*

A rapid and accurate method for the determination of oil in petroleum waxes has been developed. In this technique, all the essentials of the standard method of test for "oil content of paraffin wax" ASTM Designation D 721-47 are retained, but the sample size is reduced to 1 gram. Results by the two methods agree closely. By variation of the solvent, solvent ratio, and temperature, the procedure for paraffin waxes may be applied to microcrystalline waxes. An important feature of the method is that an ordinary analytical balance is used and no special training on the part of the operator is required. Savings can be effected in solvents, bench space, and cooling capacity. A determination may be made within an hour as contrasted with approximately 6 hours for D 721-47. This greatly increased speed should be particularly welcomed by refinery laboratories where manufacturing control in wax processing operations calls for quick determinations.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,257	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	9,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,867	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,007	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,165	224,308	16,529	82,003	6,638	62,609	8,666	57,419
November 29	5,257	5,309	224,540	16,667	86,319	6,382	61,988	8,405	56,747
December 27	5,285	5,543	222,770	17,013	91,269	7,041	50,324	9,698	51,896
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,690	40,580	9,141	50,839
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	222,814	15,783	112,991	7,682	30,717	8,854	48,334
April 24	5,415	5,517	221,652	16,515	111,128	6,831	34,237	8,877	49,572

Octane Number Blending Characteristics of Motor Gasoline Components

D. P. HEATH and J. S. HICKS.

Data are presented covering all types of octane number blending problems normally encountered in motor gasoline production, including the blending of conventional gasolines, light hydrocarbons, alkylates, catalytic polymer, and low octane number straight-run gasolines. The use of a linear volumetric procedure is recommended for the estimation of the octane numbers of motor gasoline blends containing components having octane numbers from 50 to 90. Blending octane numbers for alkylate, catalytic polymer, light hydrocarbons, and low octane number straight-run gasolines in motor gasoline blends are presented.

Evaluation of Additives and Blends for Improving the Cold Starting Characteristics of Diesel Fuels

F. L. NELSON and M. SMOLAK.

Presented are the results of a detailed study to establish the relation between Diesel fuel characteristics and their cold starting ability and to evaluate the effect of various ignition promotors on cold starting ability. The forty-odd fuels and blends evaluated in a full-scale 2-cycle diesel engine included fuels of conventional volatility and composition, blends with a synthetic distillate, and blends of conventional fuels containing volatile materials, nitrated compounds, organic peroxides, sulfur compounds, and various miscellaneous materials. Results are presented on the analysis of the full scale data to correlate cold starting ability with CFR cetane number, critical compression ratio, and autogenous ignition temperature.

Fluid Catalyst Cracking with Silica-Magnesia Catalyst

R. W. RICHARDSON, F. B. JOHNSON, and L. V. ROBBINS, JR.

The development and pilot plant testing of synthetic silica-magnesia catalyst for use in fluid catalyst cracking has been carried out in various pilot plants including the 100 barrel-per-day fluid catalyst cracking unit. The over-all results show that this catalyst is superior to synthetic silica-alumina and treated natural clay catalysts with respect to gasoline yield. The gasoline octane numbers are, however, lower than those obtained with silica-alumina, but approach those obtained with natural catalyst. The silica-magnesia catalyst is indicated to be superior from the standpoint of activity maintenance. The silica-magnesia catalyst is now in commercial production and demonstration tests in full-scale commercial cracking units will probably be made early in 1948.

Chemistry of Gum Formation in Cracked Gasoline

E. L. WALTERS, *Shell Development Company, Emeryville, Calif., and Shell Oil Company, Inc., Wood River, Ill.*, and H. B. MINOR and D. L. YABROFF, *Shell Development Company, Emeryville.*

Studies were made on stability of cracked gasolines and pure hydrocarbons by measuring the rates of gum and peroxide formation on aging. Gasoline gum appears to originate from oxidation of both reactive hydrocarbons and gasoline impurities (nonhydrocarbons). Products forming gum were found to be more difficult to inhibit against oxidation than those forming only peroxides. The gum stability of cracked gasoline was improved by treatment, inhibition, or dilution with straight-run components; boiling range was found to be important. Metal catalysts reduced gum stability but were found capable of complete inactivation by metal deactivators. Factors influencing antioxidant and deactivator behavior are discussed. Activation energies of gum-formation reactions were found to be altered by antioxidants and metal catalysts.

Effects of Steam in the Cracking of High Sulfur Stocks with Natural Catalyst

A. L. CONN and C. W. BRACKIN, *Research Department, Standard Oil Company (Indiana), Whiting, Ind.*

In the catalytic cracking of high sulfur stocks with natural catalyst, it has been found that the catalyst rapidly becomes poisoned, resulting in excessively high coke and gas yields at the expense of gasoline yield. In this paper, data are presented demonstrating the successful use of steam in solving this problem. In one set of experiments, carried out in a 2 barrel per-day fluid pilot plant, the introduction of steam to the regenerated catalyst standpipe serves to hydrate the catalyst prior to contact with oil, thus preventing loss of catalyst selectivity. In another set of experiments, including one full-scale plant test, the use of large quantities of stripping steam in addition to the hydration steam makes it possible to restore poisoned

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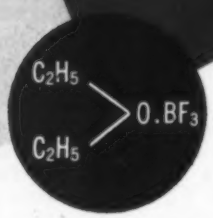

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6 Refining of aromatic and paraffinic solvents by polymerization of the olefins they contain.

7 Increasing viscosity of semi-drying and drying oils.

8 Modification of mixtures of esters and acids by polymerizing conjugated compounds selectively.

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catalyst to normal selectivity. It is concluded that the rate of sulfur poisoning is dependent upon the degree of hydration of the catalyst, the concentration of sulfur in the feed and the degree of sulfur removal in the stripper.

Method of Hydrocarbon Analysis for Gas Oils and Lube Oils

M. R. LIPKIN, C. C. MARTIN, and W. A. HOFFECKER, *Sun Oil Company, Experimental Division, Norwood, Pa.*

A general method for determining composition of gas oils and lube oils in terms of hydrocarbon types is described. Volume percent aromatics plus any sulfur and nitrogen compounds is determined with an accuracy of about 1 percent. Volume percentages of olefins, paraffins, monocyclic, dicyclic, etc., naphthenes are determined with accuracies of about 3 percent on fractions boiling over a range of not more than 200° to 250° F. Hydrocarbon type analyses for a lubricant fraction from East Texas, Michigan, Webster, and Mirando crudes are shown. In addition, procedures are given for obtaining supplementary detailed information about the aromatics and naphthenes. Complete data are shown for the 400° to 900° F. portion of Webster crude.

Origin of Petroleums and Natural Gas in the Light of Recent Research

BENJAMIN T. BROOKS.

The formation of petroleums and natural gas is considered in the light of recent work on the composition of petroleum, the presence of thermolabile constituents, data on temperature gradients, and bottom hole temperatures in fields where the composition of the petroleum has been specially studied. The relation between composition of petroleums and depth in the Gulf Coast region is regarded as particularly significant. The above facts are at variance with Rossini's conclusion that petroleum has been heated to about 400° C. sometime during its history. Other evidence is that petroleums have not ben subjected to temperatures higher than the range, 100° to 250° F. In view of the compiexity of petroleums it is concluded that clays act catalytically within this temperature range during geologic time in forming typical petroleums.

A Bearing Corrosion Test for Lubricating Oils and Its Correlation with Engine Performance

E. C. HUGHES, J. D. BARTELSON, and M. L. SUNDAY.

A description is given of a thrust bearing apparatus adaptable to the Sohio oxidation test for lubricating oils. The operating conditions and catalyst components have been worked out so that the test at 10 hours correlates for copper-lead corrosion with the 36-hour L-4 Chevrolet (ASTM) test for varied groups of inhibitors and oils. At the same time correlative information is obtained on the oxidation characteristics of the lubricating oils. One group of inhibitor-oil combinations was found to correlate poorly, although this inhibitor never attained commercial importance because it was distinctly borderline on corrosion prevention. It is indicated that the test can be best utilized by first checking correlation against the engine test for each general type of inhibitor. It is probable that the test will be found to be useful for many oils, since it is shown to be correlative for 75 oil inhibitor combinations comprising five useful inhibitors and two commercial oil types.

Composition of Shale-Oil Naphtha from Colorado Shale

JOHN S. BALL, G. U. DINNEEN, J. R. SMITH, C. W. BAILEY, and ROBIN VAN METER, *Petroleum and Oil-Shale Experiment Station, Bureau of Mines, Laramie, Wyo.*

Naphthas prepared from shale oils produced in several different retorts were compared and found to be very similar as to content by hydrocarbon groups. Consequently, one naphtha was selected for more extensive composition studies. The naphtha was separated into tar acids, tar bases, and neutral naphtha. The tar acids are mostly phenolic, but probably contain small amounts of fatty acids. The tar bases are principally pyridinic. The neutral naphtha contains approximately 30 percent paraffins and naphthenes, 45 percent olefins, 20 percent aromatics, and 5 percent sulful compounds. The paraffins and aliphatic olefins predominate in their respective groups and are largely straight-chain compounds.

NPC Short Term Group Sees Increasing Oil Supply, But Demand Also Will Rise

Petroleum supply and demand will continue in delicate balance during the 12 months ending March 31, 1949, in spite of an 8 percent increase in supply as compared with the preceding 12 months. This was the general conclusion reached at mid-April by the sub-committee on short term availability of the national oil policy committee of the American Petroleum Institute. Chairman of the subcommittee was Howard W. Page, of Standard Oil Company (New Jersey). The API subcommittee on long term supply, headed by L. F. McCollum, president of Continental Oil Company, was still working on its report.

"The race to meet the enormous increase in consumption will be close, although petroleum supplies of record proportions will be available," stated William R. Boyd, Jr., president of the A. P. I., in making public the report of the Page subcommittee.

The committee estimated that the total supply of petroleum available to meet domestic consumption for the 12 months' period starting April 1, 1948, would average 6,025,000 barrels a day, or approximately 8 percent above the demand in the similar period starting April 1, 1947. The estimate was based in part upon the forecast of the U. S. Bureau of Mines that for this period imports of oil would average 102,000 barrels per day more than exports.

"If conditions outside of its control do not retard the continued expansion of the oil industry," declared Boyd, "all former records will be surpassed by quantities of gasoline and fuel oil produced during the coming 12-month period, and if the public will practice reasonable restraint, deliveries will probably meet the increasing demands."

The subcommittee expressed belief that existing transportation facilities, plus new facilities to be completed during the period if utilized to the maximum, would provide sufficient transportation to distribute the estimated supply availability. Some of the present abnormal tank car movements will still be required, it was predicted.

In view of some spot shortages during the past winter, the subcommittee concluded that distribution problems arise whenever demand reaches 95 or 96 percent of maximum supply capacity. Consequently, full utilization of an 8 percent increase in possible supply would require continuance of spot shortages of the past, the report apparently indicated. However, the subcommittee expressed the opinion that the industry would be able to meet an increase of 4 to 5 percent in demand during the coming summer and winter periods without resorting to the various distribution expedients used last year.

"In the past," it stated, "the normal increase in demand has been about 4 or 5 percent. An increase of more than 4 or 5 percent may result in spot shortages, company allocations, and the need for aid from and individual company cooperation with state and local fuel oil coordinators in varying degrees depending on the demand. If the demand increase in any one product exceeds 4 to 5 percent, distribution difficulties may be encountered if the demand increase in other products is not correspondingly less."

Oil and Steel—Shortages Of Both Worry Experts

The calendar year 1949 military oil requirements may be at a rate 50 percent higher than the 115,129,000 barrels of products that was estimated recently for present defense establishment for a 12-month period opening with July, according to Washington experts. This projection of the military expansion appears to mean decidely smaller allocations of petroleum products for civilians than much of the industry contemplates making during fiscal year beginning July 1.

Armed forces requirements are reportedly pointed so high that U. S. economy will be "knocking right on austerity" in oil for civilians at the very beginning of a war, if one occurs in the next few years. It was pointed out that in the last war, the industry expanded to meet demands, but another war would find the industry unable to expand due to the shortage of steel. The military supply for the fiscal year now ending was 104,204,000 barrels, something in excess of 4 percent of domestic demand. It has also been pointed out that the coal strikes will not help the steel situation.

Max W. Ball, director of the Oil and Gas Division, told the Empire State Petroleum Association that steel must be exported for foreign oil development if the nation's long-range petroleum demands are to be met. Ball said that the country must consider where steel will buy the most oil supply. He warned that domestic production can not keep up with growing demand and that in 1948 the country will be a net oil importer for the first time and that the trend will continue. Ball thinks the tidelands area potentially one of the best oil areas left,

■ SEE OIL AND STEEL, PAGE 171

R-S valvEvents

Issued Periodically by R-S Products Corporation, Philadelphia 44, Pa., for Those Concerned with Flow Control and Shut-Off

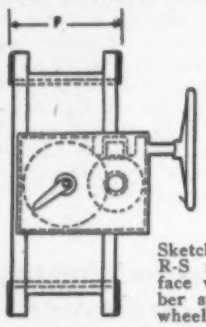
R-S SHOWS NEW VALVE IN NARROW FACE–TO–FACE SIZE

Drawing shows elevation of new R-S Valve for water service in narrow face-to-face size. It is built for 50-pound and 125-pound pressures.

This valve is made for rugged hydraulic service with a large safety factor for line stresses, water-hammer and other normal abuses.

Face-to-face dimensions follow for various available sizes:

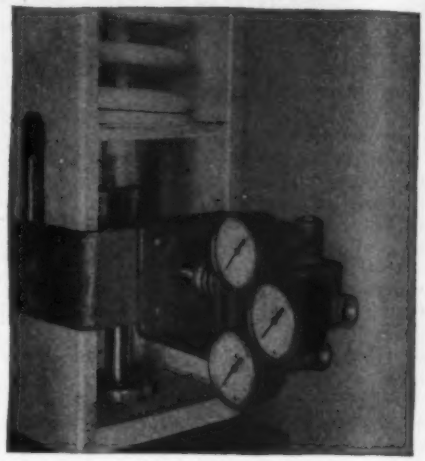
Valve Size	*F*	*Valve Size*	*F*
20″	8″	48″	15″
24″	8″	54″	15″
30″	12″	60″	15″
36″	12″	72″	18″
42″	12″	Larger sizes on request	



Sketch shows new R-S narrow face-to-face valve with rubber spool and hand-wheel control.

The face-to-face dimension includes thickness of the rubber spool with which this valve is normally provided to insure drop-tight shut-off. The valve may be had with metal-to-metal seat if preferred, in which case the face-to-face dimension is ½″ less than the figures quoted above. Because of the narrow face-to-face of this unit it is necessary to drill and tap the 4 bolt-holes on each flange that straddle the center-line of the shaft.

Sketch shows only hand wheel control but the usual hand lever, chain wheel, and chain lever controls are available, too, as well as automatic controls of many types.



Photograph showing control of R-S Valve with Hopkins Cam Positioner

The field of use of the disc type valve, with its lower cost, and capacity of two or three times that of some conventional valves, is thereby greatly widened.

New R-S Valve Representatives . . .

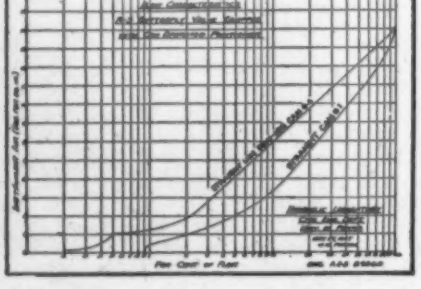
Hardly a month passes without an appointment to the growing list of R-S Valve representation throughout the States and other countries.

This month we announce new representatives in:

El Paso, Texas
Steel & Engineering Products Company
Mills Building, El Paso, Texas
Telephone Main 1770
William W. Small is in charge of this office, covering western Texas.

Toronto, Ontario
Canadian Piping & Refinery Specialties, Ltd.
2498 Yonge Street, Toronto 12, Ontario, Canada
L. T. Brodie is in charge.

Graph shows flow characteristics of R-S Valve utilizing straight Cam #1 and characterized Cam #4. *(See next column)*



R-S Announces New Cam Operated Valve Positioner

A cam-operated positioner is a key feature of a new diaphragm motor valve of the disc or butterfly type just announced by R-S Products Corporation. Excellent control of flow characteristics is attainable by simply changing cams in the field on the cam-operated positioner, which, in effect, adds to the normal functions of the disc type valve. The desirable characteristics of a straight line semi-log curve, linear, or almost any other special characteristics to suit individual process requirements, are within the range of the new positioner.

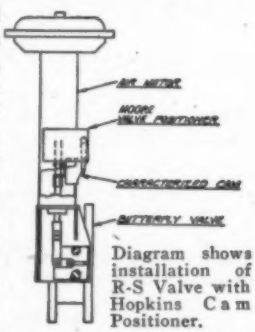


Diagram shows installation of R-S Valve with Hopkins Cam Positioner.

Replacing of one cam on the positioner with another of a different shape permits the retention of the basic advantages of the disc type valve while adding special flow characteristics typical of other valve types. Air motor shown in sketch above utilizes up to 50 p.s.i. operating air pressure. Valve positioner utilizes 0 to 15 p.s.i. instrument air. The cam-operated positioner is also available using hydraulic or air cylinder instead of air diaphragm motor. *(Continued in next column)*

An Oft-told Tale!

"Occasionally," says Russell C. Ayers, Sales Manager of the R-S Valve Division, "we note valve and fitting suppliers advertising magnesium and aluminum castings as if they were a discovery."

"The fact is that these metals are not novelties in valve manufacture. R-S has been making valves of magnesium, aluminum, and other light metals, and many alloys for a great many years."

"Further, we make our valves of any material that can be cast or welded, even including plastics for certain purposes."

The New R-S Valve Catalog #17

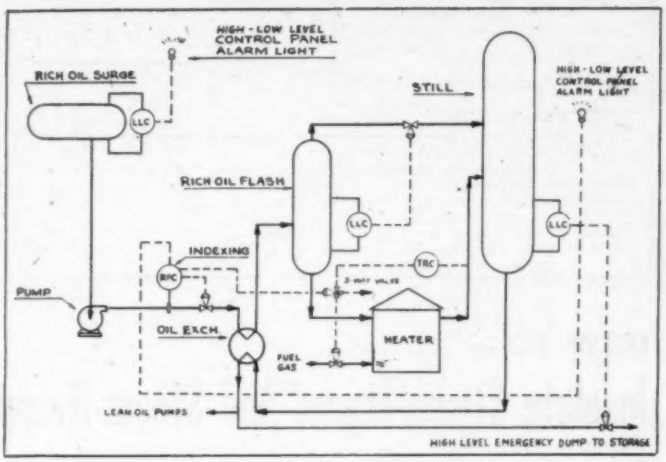
R-S Valve Catalog #17 is packed with information for engineers. There are over 70 halftone pictures of R-S Valves . . . working drawings of 21 types of R-S Valves with standard controls and fittings and complete dimensional data for all sizes . . . working drawings of 22 types of prime movers . . . numerous other diagrams, graphs and miscellaneous drawings. Address R-S Products Corporation, Valve Division, Philadelphia 44, Pennsylvania.

JMLco P-EE2

OPERATION HOW TO DO IT MAINTENANCE

HOW A—
Control System Protects Plant's Rich Oil Heater

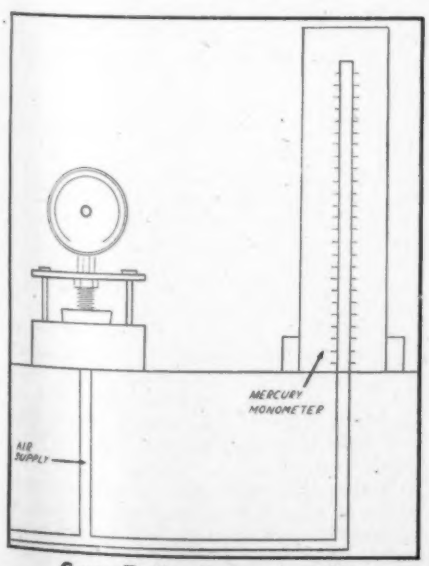
ONE of the methods of instrument-controlling rich oil heaters to obtain trouble-free operation and protection in an emergency, is in use at the Vanderbilt, Texas, gasoline plant of Magnolia Petroleum Company. As shown in the sketch, rich oil is pumped under flow control from the rich oil surge drum through the lean oil-rich oil heat exchangers to a rich oil flash drum. Flashing the oil in the drum reduces the heat load of the rich oil furnace and still, because the vapor that has been heated with the oil in the rich-lean oil heat exchangers flows from the separator to the still at a lower temperature than the rich oil stream from the heater. Liquid level in the flash drum is maintained by means of a vent line control valve that closes on an increase in liquid level and thus holds sufficient pressure on the drum to force all liquid residue to flow through a direct-fired heater to the still. It should be noted that this level control arrangement on the flash drum provides the minimum pressure in the drum and permits maximum vaporization to occur.



To keep the system in balance, a liquid level controller on the still actuates an indexing mechanism, which adjusts the recording flow controller to the correct value. This combination of liquid level and flow control is used to provide smoother flow through the heater than could be obtained with a straight liquid level controller.

The heater outlet temperature control is entirely conventional in its regulation of fuel gas to the heater's combustion chamber, but does have an additional safety precaution. If the flow of rich oil through the recording flow controller falls below a predetermined value, the furnace control valve is closed—shutting off the fuel gas and preventing coking in the furnace tubes.

If the charge pump stops, the flow recording controller shuts off the fuel gas. Also, when the liquid level in the surge drum falls below the predetermined level, an alarm signal light on the unit control panel warns the operator of the emergency condition.



Gauge Testing System Assembly

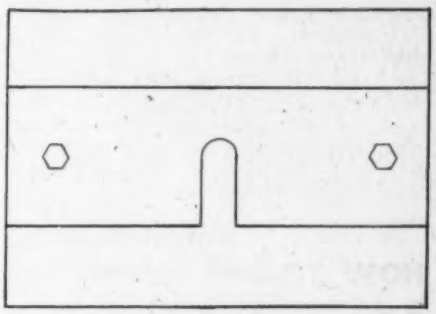
HOW TO—
Check Reid Vapor Pressure Gauges

AN ASSEMBLY for checking the Reid vapor pressure gauges used in determining the vapor pressure of gasoline, has been devised by Loy Orren at the Baytown refinery of Humble Oil & Refining Company.

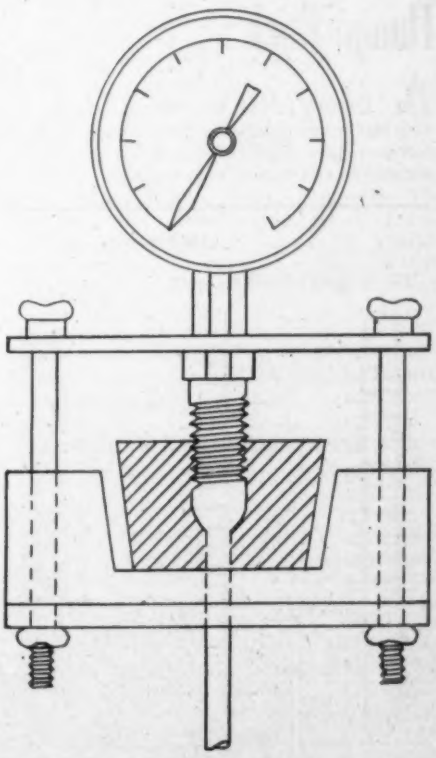
By the old method of attaching the gauge to the testing manifold, the gauge in many instances would face the wall when made up. The gauge in this position was difficult to read and comparison with the mercury manometer was awkward. The technician testing the gauge, also, had to exercise caution in protecting the gauge chuck tip as the tip is ground to match the connection on the expansion chamber of the testing assembly. Should the chuck tip become scratched or marred, the vapor testing assembly would leak resulting in an erroneous answer.

Orren's assembly consists of a well which is connected to the manometer manifold. A Neoprene rubber stopper with a hole slightly smaller in size than the gauge chuck fits into the well and provides a pliable seal between the chuck and the manometer line. A plate fits on the shoulder of the gauge chuck and downward pressure is applied by tightening two bolts connected to the well body. The pressure provides a vapor-tight connection between the gauge and manometer line.

The rubber stopper eliminates the possibility of marring the chuck tip. The gauge always faces the technician testing the gauge and can easily be read for comparison with the mercury manometer.



Anchor Plate to Hold Gauge Assembly in Well



Well Cross-Section

HOW TO—

Caculate Quantity of Catalyst Carryover

THE engineering department of the Root Petroleum Company, at its El Dorado, Ark., refinery uses a heat balance to calculate the quantity of catalyst carryover from the regenerator of their fluid type catalytic cracking unit.

The factors necessary for the calculation are T1, the temperature of the carrier air which is used to return the Cottrell fines to the regenerator; T2, Cottrell catalyst temperature; T3, air and catalyst mixture temperature, (this temperature is taken at a point about 1/3 way upon the fines return line); the specific heat of the catalyst, about .25; the specific heat of air, about 24; and the volume of carrier air.

By means of a heat balance wherein the heat lost by the Cottrell catalyst is equal to the heat gained by the carrier air, the following are obtained:

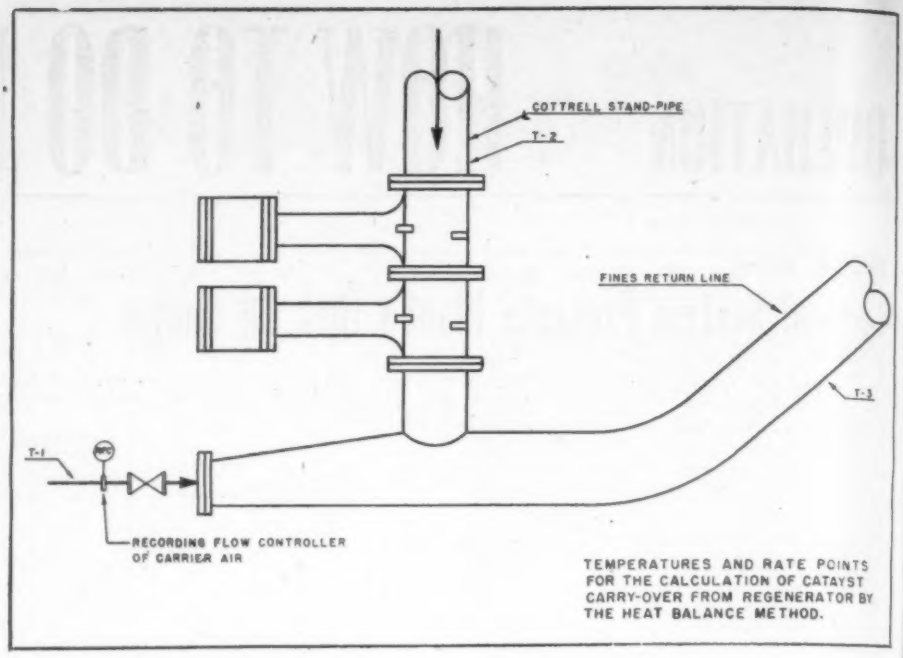
(Lbs/Hr Catalyst) (.25) (Cottrell catalyst temperature minus air and catalyst mixture temperature) equals (Lbs/Hr Air) (.24) (Air and catalyst mixture temperature minus Temperature of the carrier air).

Therefore:

$$\text{Lbs/Hr catalyst} = \frac{(\text{lb/hr air})\ (.24)\ (T3 - T1)}{.25\ (T2 - T3)}$$

or

$$\text{Tons/Day} = (.0115)\ (\text{Lb/hr air})\ \frac{(T3 - T1)}{(T2 - T3)}$$

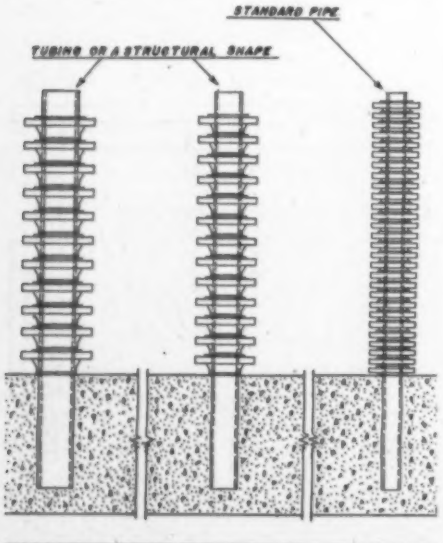


TEMPERATURES AND RATE POINTS FOR THE CALCULATION OF CATAYST CARRY-OVER FROM REGENERATOR BY THE HEAT BALANCE METHOD.

HOW TO—

Fabricate Convenient Flange Rack

A CONVENIENT flange rack for storing various types and sizes of pipe flanges can be fabricated by setting a series of upright pipes in a concrete base. The flanges are slipped over the upright pipes to form orderly stacks.

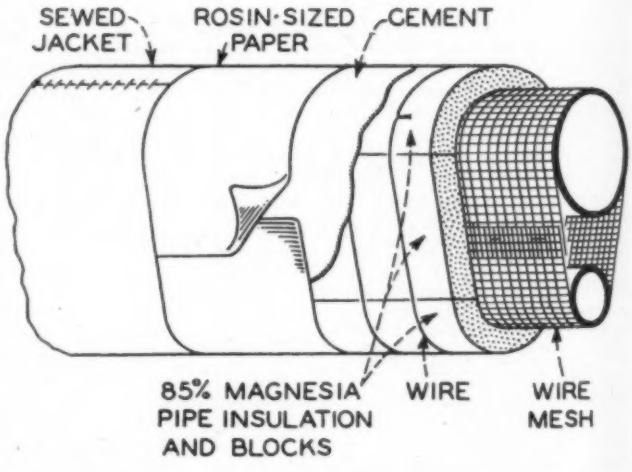


The diameters of the upright pipes vary to correspond with the size of the flange stacked and by stacking the flanges according to type and size a constant inventory may be maintained.

HOW TO—

Insulate Steam-Traced And Steam-Wrapped Lines

SUGGESTIONS on insulation of steam-traced or steam-wrapped piping with molded insulating materials such as 85 percent magnesia or diatomaceous silica are offered by the Magnesia Insulation Manufacturers Association.



In the case of steam-traced piping, a steam line, generally an inch or less in diameter, is run parallel to a process line carrying material which must be kept hot. With steam-wrapped piping, the steam line is wrapped spirally around the process line. In either case the insulation construction should surround both pipes so as to permit the heat to be transferred from the steam to the process line.

With steam-traced lines, half-sections of semi-cylindrical molded pipe insulation, each half of a size appropriate for its respective line, should be fitted around the process line and the steam pipe. At the two sides, blocks of the same thickness as the pipe insulation and cut to fit, should be carefully fitted between the semi-cylindrical sections. The half-sections and the side blocks should be tightly butted together and firmly fastened in place with iron wire. All the joints should be pointed up with asbestos cement, and the entire outer surface covered with a layer of the cement reinforced with hexagonal wire mesh and troweled to a smooth, hard finish.

In some cases, before the insulation is applied, the two lines may be wrapped with wire mesh.

Steam-wrapped piping should be covered with a layer of galvanized expanded metal lath, laced in place with iron wire. The lath serves as a firm foundation for the insulation which should then be applied. Semi-cylindrical or segmental pipe insulation should be used, the size of the insulation depending upon the diameter of the process pipe plus the steam pipe. Insulation application is the same as for any pipe insulation job. The insulation sections are applied, joints butted tightly together, and fixed in place with iron wire.

Depending upon the operating conditions involved, various finishes such as cement, sewed canvas, asphalt saturated asbestos roofing felt, metal jackets, etc., may be used to cover the insulation.

THE MONTH IN THE INDUSTRY

Regular Middle East Oil Planned by Socony-Vacuum

Plans to increase its importation of crude oil from the Middle East starting in May, to augment needed supplies in this country, were announced last month by Socony-Vacuum Oil Company, Inc. Imports will average 17,000 barrels daily and after January 1, 1949, will increase gradually to 40,000 barrels. The increased shipments of crude oil will come mostly from Iran and Kuwait.

Socony-Vacuum has been bringing in crude oil from Saudi Arabia to its Paulsboro (N. J.) refinery since July 1947 and importing crude from Iran and Kuwait is a continuation of the practice. Socony-Vacuum's project will be one of the first whereby a regular schedule of shipments from the Middle East will be in effect.

Socony-Vacuum has chartered 11 tankers of the T-2 type, or equivalent, to transport the oil. In addition, the company has arranged to have built seven new tankers, each of 26,500 tons deadweight. Three of these new tankers are scheduled to be ready for use in 1949. The one-way trip for tankers from the Persian Gulf to Paulsboro takes about 30 days, including loading and discharging.

Crude Oil Survey Letters Sent by Senate Group

Information on the nation's crude oil picture is being sought by the Senate Small Business (Wherry) committee by questionnaires mailed to 145 crude producers and refiners.

The questionnaire will ask for information from January 1, 1946, to date on crude production per month, crude purchases in barrels per day, crude received on processing deals, and total crude storage at end of month.

A committee spokesman said that the important problem was the crude oil supply, and that other questionnaires in the works on refining, transportation, and marketing, will not be sent out if the situation eases.

Oil and Steel

■ CONTINUED FROM PAGE 165

but does not think that disputes over it will be settled in the near future. The supply of tankers, he said, will be adequate for 1949, but he foresaw a tanker shortage by 1950.

Summing up the situation, observers see future beyond coming fiscal year as relatively little brighter. The armed forces have some prospects of more than the 60,000 barrels per day currently drawn from the Persian Gulf, but Middle East oil to this country will be cut off if an emergency develops. Anyway, observers say, this oil supply will gradually diminish because Europe will absorb it; although, vanishing point is four years or more off according to European recovery plan. Synthetics are a long range proposition and as a substitute source of energy in ordinary sense are long ways off. Stockpiling of crude is not being considered, because refiners need every drop available, and also, the idea is hardly feasible. Probably the best promise of meeting demands is expansion of various phases of domestic industry, Western Hemisphere production generally, and tidelands production in particular, but these phases can come about only gradually.

Meetings

May

10-13—API Division of Refining Mid-Year Meet, Philadelphia, Benjamin Franklin Hotel.
10-13—National Fire Protection Association, Washington, D. C., Statler Hotel.
15-22—International Petroleum Exposition, Tulsa.
24-26—American Gas Association, joint production and chemical conference, Asbury Park, N. J., Berkeley-Carteret Hotel.
24-28—API Agricultural Development Committee spring meet, Madison, Wis., Lorraine Hotel.
27-28—Natural Gas & Petroleum Assn. of Canada, Niagara Falls, Ontario, General Brock Hotel.
30—to June 4—ASME semi-annual Meeting, Milwaukee, Wis.
31—to June 6—Liquefied Petroleum Gas Assn. annual convention and trade show, Sacramento, Calif.

June

1- 3—Petroleum Industry Electrical Assn., Dallas.
1- 6—LPG Association, Inc., annual convention and trade show, Sacramento, Calif.
2- 4—Annual Short Course in Gas Technology, Texas A. & I. College, Kingsville.
2- 5—Short Course in LP-gas appliances, University of Tulsa.
6- 8—Petroleum Equipment Suppliers Association, Colorado Springs, Broadmoor Hotel.
7-11—Pittsburgh International Conference on Surface Reactions, Mellon Institute, Pittsburgh.
20-23—American Society of Agricultural Engineers, Portland, Ore., Multnomah Hotel.
21-25—American Society for Testing Materials, annual meeting, Detroit, Book-Cadillac Hotel.
30—to July 2—API, Eastern Spring Meet, White Sulphur Springs, Va., Greenbrier Hotel.

September

13-17—Third Instrument Conference and Exhibit, Philadelphia, Convention Hall.
15-17—National Petroleum Assn. meeting, Atlantic City, Hotel Traymore.
16—API Lubrication Committee, Atlantic City, Hotel Traymore.
20-22—National Butane-Propane Association, Chicago.
27-28—Independent Petroleum Association of America, San Antonio, Plaza Hotel.

October

4- 9—American Gas Association convention, Atlantic City, Ambassador and other hotels.
8—California Natural Gasoline Association, annual fall meeting, Los Angeles, Ambassador Hotel.
11-13—National Lubricating Grease Institute, annual convention, Chicago, Edgewater Beach Hotel.
12-16—National Chemical Exposition, Chicago, Coliseum.
14-15—Indiana Independent Petroleum Association, Indianapolis Hotel Severin.
14-15—Texas Mid-Continent Oil & Gas Association, Fort Worth.
15-16—American Oil Chemists Society, New York.

November

8-11—American Petroleum Institute annual meeting, Chicago, Stevens Hotel.
29—to Dec. 4—18th National Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.

Johnson and Fenex Given Promotions by Continental

D. R. Johnson, superintendent of Continental Oil Company's Ponca City, Okla., refinery, has been named southern region refinery superintendent, and will supervise operations of plants at Ponca City; Lake Charles, La.; Wichita Falls, Texas, and Artesia, N. M. His headquarters will be in Ponca City.

J. E. Fenex, superintendent of Continental's Lake Charles refinery, has been appointed western region refinery superintendent, with headquarters in Denver. He will supervise operations of plants at Denver; Glenrock, Wyo.; Farmington, N. M., and the new $8.5 million refinery under construction by Continental at Billings, Mont.

Both men will work under direct supervision of H. G. Osborn, Continental Oil Company vice president in charge of manufacturing.

Johnson has had 24 years of service with Continental, and Fenex 26 years, and both men have advanced through the ranks of the company's manufacturing department.

Succeeding Johnson as superintendent of the Ponca City refinery is L. W. Vickery, who has been assistant superintendent since February, 1943.

H. R. (Pete) Wall, who has been assistant superintendent of the Lake Charles refinery since August, 1942, succeeds Fenex as superintendent of that plant.

Edmister Named Professor At Carnegie Tech Institute

Wayne C. Edmister of Scarsdale, N. Y., who supervised process design of the atomic pile (nuclear reactor) at the Brookhaven National Laboratory on Long Island, has been appointed a professor of chemical engineering at Carnegie Institute of Technology.

Edmister, a native of Cleveland, Okla., is senior chemical engineer and assistant director of process development for Hydrocarbon Research, Inc., New York, and is adjunct professor of chemical engineering at New York University. He has taught at Illinois Institute of Technology, where he did part of his graduate work; at the evening school of the Standard Oil Company, (Indiana) and at N.Y.U.

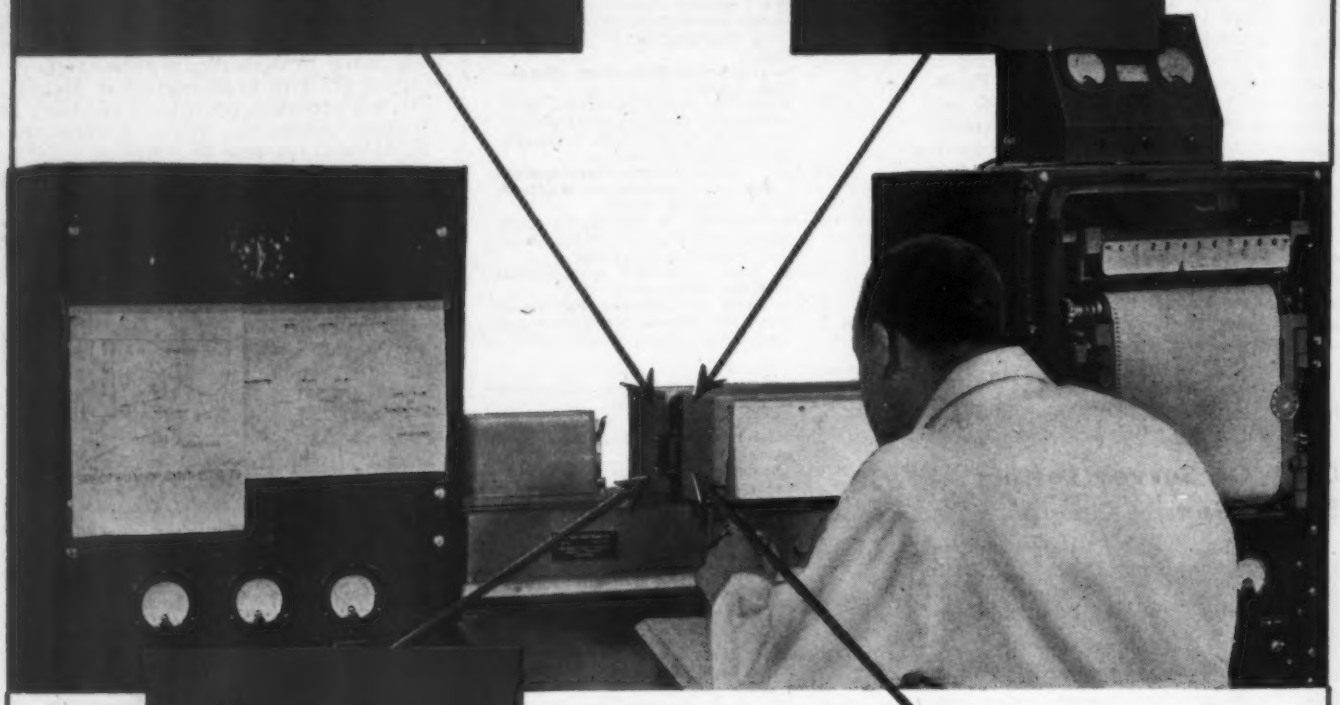
Edmister is author of a series of articles running currently in PETROLEUM REFINER, "Application of Thermodynamics to Hydrocarbon Processing."

Chemical Development Group Announces Officers

Recently elected officers of the Commercial Chemical Development Association for the year beginning April 1, are President, Lauren B. Hitchcock, Quaker Oats Company; vice president, J. H. Boyd, consultant; treasurer, C. D. Goodale, Commercial Solvents Corporation; executive secretary, F. A. Soderberg, General Dyestuff Corporation; directors, W. H. Bowman, Jefferson Chemical Company; W. H. Harding, American Cyanamid Company; K. H. Klipstein, Calco Chemical Division, American Cy-

This man is working for You!

He is finding out what basic properties of petroleum products go along with better performance.



. . . Investigating the fundamental composition of petroleum and petroleum products with an infra-red spectrometer.

What he learns is applied to guide the development of new and better additives—new and better PARAMINS.

This knowledge in the hands of the many research scientists and technicians using the facilities of America's largest petroleum laboratories can help improve your products when you use PARAMINS.

PARAMINS* make good motor oils and fuels better!

ADDITIVES WITH A BACKGROUND

PARAMINS ADDITIVES ARE KNOWN BY THE BRANDS:

PARATONE —*for improved viscosity index.*
PARAFLOW —*for lower stable pour.*
PARATAC —*for tacky oils and greases.*
PARAPOID —*for E.P. gear oils.*
PARANOX —*for inhibiting corrosion and oxidation.*
PARASHEEN —*for better appearance.*
PARADYNE —*for improved gasoline.*

ENJAY COMPANY, INC.

*Trade Mark

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anamid Company; and J. J. Schaefer, Wyandotte Chemicals Corporation.

Membership of the Commercial Chemical Development Association comprises those in responsible charge of technical service, market research, market development, product development, application research, or other activity contributing directly to the commercial development of chemicals.

Dr. Peavy Heads Houdry Sales and Engineering

Dr. Claude C. Peavy, who for the past few years has been chief engineer for Houdry Process Corporation, Philadelphia, has been elected vice president in charge of sales and engineering.

Dr. Peavy came to Houdry from Socony-Vacuum Oil Company's refinery engineering division where he was chief process engineer. Prior to his five years' service with Socony-Vacuum, he had been an engineer with the E. B. Badger and Sons Company for nine years. During his service with Badger he worked on the design of the first commercial Houdry fixed-bed units and also saw engineering service in foreign countries.

Catalytic Construction Names New Officers and Directors

Directors of Catalytic Construction Company, Philadelphia, last month were elected exclusively from operating management as follows: John D. M. Hamilton, David N. Hauseman, W. Graham Jamison, Alan T. Knight, Harmon J. Monnik, Claude C. Peavy, and T. Ellwood Webster.

Officers include: David N. Hauseman, chairman of board; T. Ellwood Webster, president; Alan T. Knight, vice president; Claude C. Peavy, vice president; John D. M. Hamilton, secretary; W. Graham Jamison, treasurer, comptroller and assistant secretary; and John A. Schumacher, assistant treasurer.

NPC Groups Reactivated

Reactivation of three committees to bring to date earlier reports on petroleum production and crude availability, domestic refining capacity and tanker transportation, has been announced by Chairman W. S. Hallanan of the National Petroleum Council. Production and crude availability committee will be headed by B. A. Hardey; domestic refining capacity committee by R. E. Wilson; and the tanker transportation committee by James Patterson.

New members on the refining capacity committee include Reid Brazell, Leonard Refineries, and Henry Zoller, Derby Oil Company.

Co-ops Back on NPC

Reappointment of Howard A. Cowden, of Consumers Co-operative Association, Kansas City, Kan., as a member of the National Petroleum Council by Interior Secretary Krug again gives the co-ops a voice in the NPC. Several members of the NPC were dropped at the end of 1947, Cowden among them, for non-attendance at the council meetings.

New Oil Research Laboratory Dedicated

Standard's New Laboratory Plant at Whiting, Ind.

The petroleum industry is an outstanding example of what industrial research has done to improve products, increase yields, broaden the scale of commercial operations, and bring to the public new products to increase efficiency and human comfort, A. W. Peake, president of Standard Oil Company (Indiana), declared last month when Standard's new Whiting, Ind., research laboratory was dedicated. Leaders in business, finance, education, and science from throughout the United States were conducted through the new laboratory as a part of the dedication.

"Research and management constitute a closely knit partnership," Peake said. "While skillful research develops new products and processes of future monetary advantage to the company, management must carry on its commercial activities to provide the money for tomorrow's research. Without the profit motive, there would be no industrial research; and it is probably just as true that, without research, there might be no profits in the future."

Elimination of major international war appears a by-product of the continued growth of science if nations will work together in harmony as did the scientific specialists who made the atomic bomb, Dr. Arthur H. Compton, chancellor of Washington University, declared in a dedication talk.

"Perhaps never has been achieved more extensive and complete cooperation among such widely varied groups as in the gigantic task of making the atomic bomb," said Dr. Compton, who was present when the first demonstration of an atomic chain reaction was accomplished in a war laboratory of the University of Chicago in December, 1942.

"All worked with coordinated efforts. Many differences arose, but these were set aside in order to reach the common goal. Enormous strength resulted from such a team of coordinated specialists.

"World government that will keep in ordered relation the work of the many nations is the inevitable goal toward which the great forces of social evolution are rapidly moving. In this integrated world community, harmony of activity is necessary and conflicts between groups must be resolved with minimum interference with others. Elimination of major international war appears thus a sure by-product of the continued growth of science."

Dr. R. E. Wilson, Standard's chairman, emphasized that the new laboratory was not brick and mortar alone but an organization of scientists. He pointed out that the company's refineries are almost entirely supervised by chemists and engineers from general foremen up to managers. Seven chemists or engineers are members of the board of directors. In addition to Dr. Wilson, Mr. Brown, and Mr. Roberts, they are A. W. Peake, president; Dr. Max G. Paulus, vice president in charge of manufacturing; Harry F. Glair, general manager of manufacturing; and F. O. Prior, vice president in charge of production.

Development of fuels, lubricants, and 2000 other petroleum products for transportation, industry, and the farm and home together with research on new insecticides, plasticizers, synthetic cleansing agents, and refining processes will be carried on in the new Whiting laboratory. When all units of the laboratory are completed they will house 340 chemists, chemical engineers, physicists, entomologists and other scientists, along with 800 technicians and other assistants.

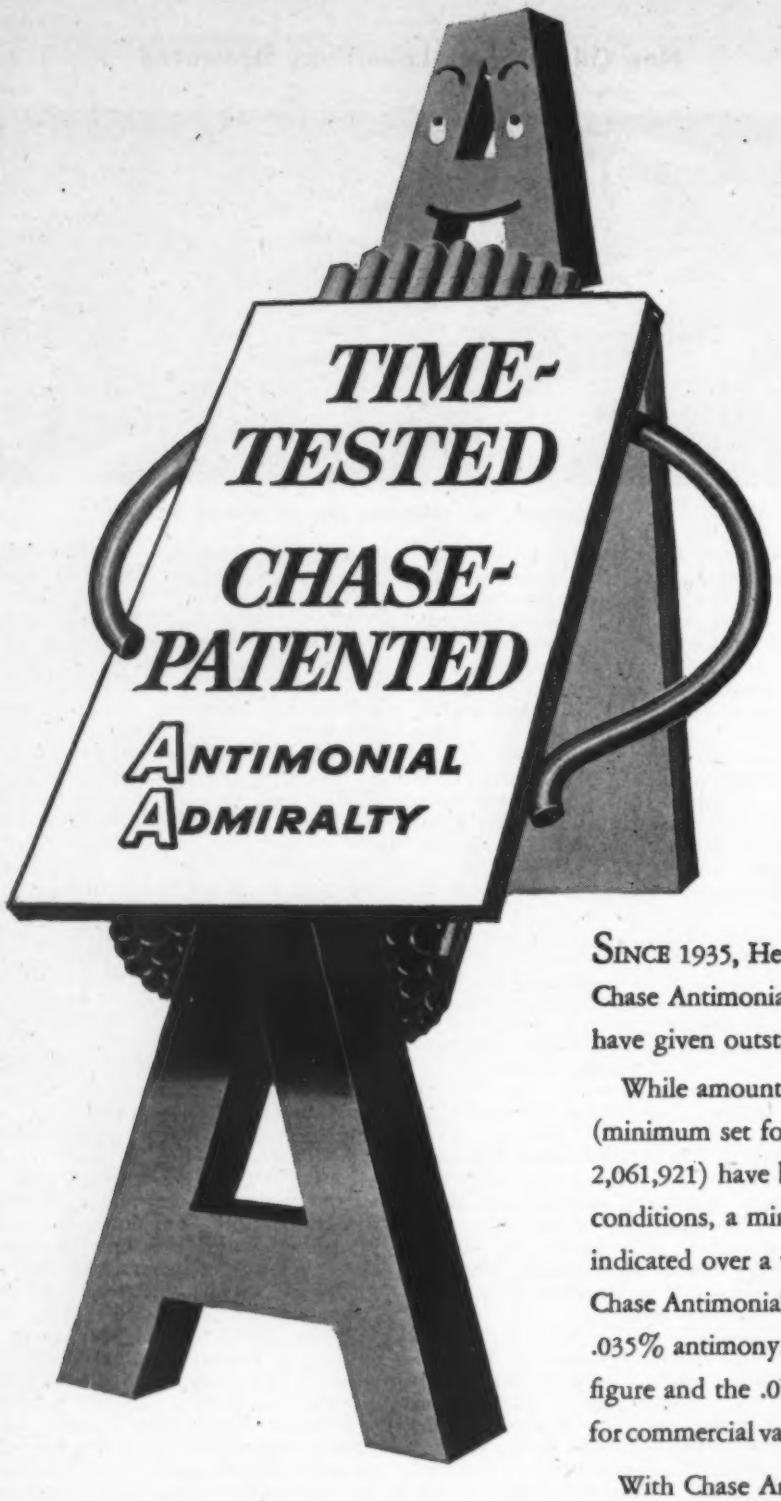
A feature of the Whiting research laboratory is the fact that practically all the steps of research are carried out in one location — exploratory research, pilot-plant work, economic studies, and ists, chemical engineers, physicists, engaged in carrying out technical service to manufacturing located near by, in the Whiting refinery, it is possible to have present at research discussions technical men who have approached each problem from a number of different angles.

Related departments, such as the patent department, have representatives permanently assigned to the laboratories, in constant contact with the research men and design engineering and operating department personnel are situated conveniently close by.

Ball Asks That Search Start for a Successor

Max W. Ball, director of the Oil and Gas Division of the Department of Interior, last month told the National Petroleum Council that inasmuch as he did not propose to remain with OGD indefinitely, the council had better locate an individual with oil experience who could serve for a time as assistant to him and then take over as director on his departure.

A special committee has been appointed to hire an assistant to Ball and if



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While amounts of antimony as low as .007% (minimum set forth in Chase Patent No. 2,061,921) have been satisfactory under mild conditions, a minimum of about .015% is indicated over a wide range of applications. Chase Antimonial Admiralty contains nominally .035% antimony. The difference between this figure and the .015% is the Chase allowance for commercial variation sometimes encountered.

With Chase Antimonial Admiralty, you obtain a strong safeguard against dezincification at no extra cost! Write or phone your nearest Chase Warehouse or Sales Office, for additional information.

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NEWARK NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH PROVIDENCE ROCHESTER† SAN FRANCISCO SEATTLE ST. LOUIS WATERBURY (†Indicates Sales Office Only)

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and when Congress votes larger appropriations, hire six more technical men. The committee comprises: Reid Brazell, Leonard Refineries; Brewster Jennings, Socony-Vacuum Oil Company; J. Howard Marshall, Ashland Refining Company; A. Jacobsen, Amerada Petroleum Corporation, and H. T. Ashton, Western Petroleum Refiners Association.

Stanolind Names Cubbage Operating Superintendent

Thomas L. Cubbage has joined Stanolind Oil and Gas Company as operating superintendent in the manufacturing department.

Cubbage, formerly plant superintendent of the government-owned, Phillips Petroleum Company-operated Plains Butadiene plant at Borger, Tex., will supervise the operations of Stanolind's gasoline and cycling plants and its refinery at Superior, La.

E. J. Yocom has been named plant superintendent of Stanolind's cycling plant at South Jennings, La. Yocom had previously been plant foreman.

A. C. Andrews has been named field project engineer and will supervise the construction of Stanolind's Burnell-Horth Pettus cycling plant at Pettus, Texas. Andrews was formerly operating engineer at Stanolind's Hasting Plant near Alvin, Texas.

Other members of the Stanolind's organization recently promoted or transferred include Robert A. Feagan promoted to process engineering supervisor in the manufacturing department, Tulsa general office; D. W. Farnham, promoted to project engineer; Henry K. Boswell, Loren L. Buck, Ernest O. Patterson and Richard E. Pearson promoted to mechanical engineering group leaders; Alexander Clark, Jr., sales engineer transferred from Houston, to Tulsa, and G. H. Lancaster, petroleum engineer, transferred from Midwest, Wyo., to Rangely, Colo.

Clyde Foster Promoted

Election of Clyde T. Foster has been named executive vice president of The Standard Oil Company (Ohio). Foster joined Standard Oil in 1929 as special assistant to the sales manager and successively held the positions of manager of the service station department, manager of the operating department of the sales department, and assistant to the president. He was named a vice president in January of 1946 and elected to a directorship in September of that year.

Cost Accountants Meet

The National Association of Cost Accountants' first Southwestern regional cost conference, held last month in Dallas, attracted more than 200 cost accountants, controllers, auditors, teachers of accounting and company executives from Texas, Oklahoma, Louisiana, Colorado, Missouri, Tennessee and Kansas.

Discussion leaders furnished by participating chapters gave detailed reports on membership, member attendance, programs, meetings, employment, education, publications, and publicity.

Opposition to Washington Control of Oil Expressed as Western Refiners Hold Meet

A stinging blast that laid bare and condemned the efforts of government agencies to obtain control of the petroleum industry was delivered by Walter S. Hallanan, chairman of the National Petroleum Council, at the Western Petroleum Refiners Association Convention in Galveston, Texas, April 4, 5, and 6.

Hallanan warned that only a free and healthy oil industry can meet the tremendous and ever-increasing demand for petroleum products, pointing out that the very essence of productivity lies in the freedom of the producer. Natural resources of oil are worthless without men of courage and vision to discover, develop, and process them, and even then such a combination requires a political climate that will encourage and protect individual initiative, he declared.

A campaign is under way, the speaker said, to bring the oil industry under government control. "But government directives," he reminded, "cannot produce a single additional barrel of oil; they can only impede and retard production. If materials could be obtained for drilling and production, the oil industry will spend $5 billion to expand."

In commenting on the tidelands case, Hallanan declared that the Supreme Court's decision in the California tidelands case had placed a potential bomb under American property rights. The court's decree that the federal government has "paramount rights in the dominion over" resources of the tidelands could logically be applied to any property deemed to be essential to the national defense, he said. The industry could not function effectively or quickly in tidelands development "under the red tape bureaucratic regulation and absentee landlordship of the federal government."

Officers Re-elected

H. T. Ashton of Socony-Vacuum Oil Company, Inc., was re-elected president of the Western Petroleum Refiners Association for his third successive term. All other officers and directors were re-elected, except that Roland V. Rodman was elected a director to succeed L. H. Prichard, Anderson-Prichard Oil Corporation.

In his welcoming address, Ashton told the more than 650 industry personnel attending that from present indications, the summer and winter ahead will tax the capacity and ingenuity of the industry after satisfying governmental requirements. The present annual domestic consumption of petroleum products is at the rate of 600 gallons per capita; ten years ago it was 367 gallons, he said.

W. M. Holaday, Socony-Vacuum Oil Company, Inc., speaking on "Motor Fuel Trends," asserted that the octane number level of motor gasoline will not increase as rapidly as in the past, giving as his reason that the industry must spend more than $4 billion during the next several years to meet quantity demands alone. Some increase in anti-knock value should result from installation of modern equipment in this program, he said.

In his presentation, Holaday told the group that improvements will be made in fuel economy by use of high compression engines and automotive design and motor fuel marketing policies. Also, he said that barring political upsets, we should anticipate no long term shortage of crude oil.

"Improving Engine Lubricating Oils Through the Use of Additives" by C. J. Livingstone and W. A. Howe, Gulf Oil Corporation, revealed that approximately 51 characteristics of lubricating oils can be affected by additives. Most important of the 51 characteristics are resistance to oxidation, prevention of bearing corrosion, detergency, high viscoisity index, low pour point, resistance to foaming, and prevention of rust.

Dr. R. W. Krebs, Esso Laboratories, Baton Rouge, La., reported in "Application of the Fluid Catalyst Technique to Catalytic Cracking and Hydrocarbon Synthesis," that if the petroleum industry starts production of synthetic oil, it will immediately become the major producer of basic organic chemicals. See page 115 for his complete discussion.

Gas Synthesis Discussed

In the general session, presided over by R. L. Tollett, Cosden Petroleum Corporation, the assembly was welcomed by William J. Murray of the Texas Railroad Commission, representing Governor Jester.

"Oil Shale as a Source of Synthetic Liquid Fuels" by Boyd Guthrie and John G. Tripp, Oil Shale Demonstration Plant, U. S. Bureau of Mines, Rifle, Colo., was a discussion of the potentialities of oil shales as a source of fuel oils and the current operations of the Bureau of Mines at Rifle.

"Appraisal of Gas Synthesis Operations" by R. C. Alden and A. Clark, Phillips Petroleum Company, reported the outlook for natural gas synthesis was favorable, but warned that the ultimate success of the program depended on new gas discoveries. The authors listed eight specific points concerning synthesis plants and their operation.

J. Copeland Gray, member of the National Labor Relations Board, Washington, D. C., delivered an address on "How Goes the Labor-Management Relations Act" before the association's closing general session, in which he discussed legislation and results of the Taft-Hartley and Wagner Acts. W. T. Holliday, The Standard Oil Company, Cleveland, Ohio, spoke on "World Federation."

Pure Announces Personnel Changes at Smiths Bluff

A number of local management and staff promotions haye been announced for the Smiths Bluff refinery of The Pure Oil Company as follow:

J. S. Allen, present superintendent, becomes manager of the refinery; Irwin L. Hostetler, assistant superintendent, becomes general superintendent; Norman S. Banta, superintendent of light oil operations; Robert F. Davies, assist-

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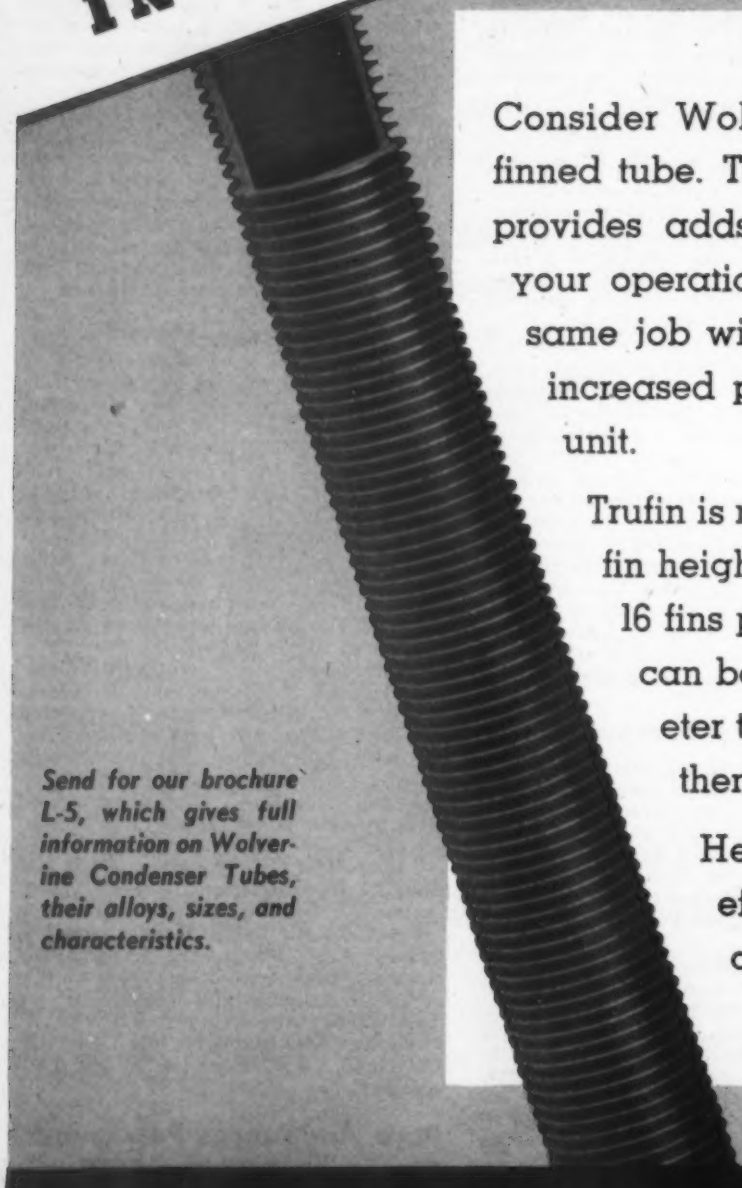

Consider Wolverine Trufin—the integral finned tube. The extended surface area it provides adds so much extra efficiency to your operations that you can (1) do the same job with a smaller unit or (2) gain increased performance using the same unit.

Trufin is made in various fin spacings, fin heights and alloys. In the case of 16 fins per inch, the ends of the tube can be of sufficient Outside Diameter to facilitate rolling or brazing them into a tube sheet.

Here's extra condenser tube efficiency really worth your consideration.

Send for our brochure L-5, which gives full information on Wolverine Condenser Tubes, their alloys, sizes, and characteristics.

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ant superintendent of light oil operations; Joe B. Price, assistant superintendent of lube oil operations; Roland P. Wood, superintendent of construction and maintenance; William G. Nelson, superintendent of maintenance and William E. Roden, assistant superintendent of maintenance.

James H. Heslar continues as superintendent of construction.

Supreme Court Denies Farben Patent Case Review

A suit by Standard Oil Company (New Jersey) and three subsidiaries to regain certain I. G. Farben synthetic oil and rubber patents seized during the war by the Alien Property Custodian has been declined for review by the Supreme Court. A lower court had awarded the companies the Farben stock and patents acquired before October, 1939, but held that government should retain all acquired subsequently. The Justice Department opposed the appeal, charging that the four companies approached the court with "unclean hands."

The companies making the appeal included Standard Oil Development Company, Standard Catalytic Company, and Jasco, Inc.

Du Pont Company Outlines Research Expansion Plans

A $30 million expansion of research facilities at E. I. Du Pont de Nemours and Company's experimental station here has been approved by the executive and finance committees and submitted for ratification to the directorate.

Called the biggest single laboratory project the company has ever undertaken, it will make the Wilmington, Del., experimental station, one of the largest research establishments in the world.

Some of the company's research organizations now located elsewhere will transfer to the new facilities which include ten new laboratory and semi-works buildings for long-range research and development of new chemical discoveries. Existing laboratory buildings for nylon and other products will be enlarged. There are also to be 13 new service buildings.

Aall Gets Research Post

Dr. Christian H. Aall has been promoted to the newly created position of field research technologist for Monsanto Chemical Company's plant at Monsanto, Tenn. He will be in immediate charge of research to develop improvements in existing operations at the Tennessee plant on matrix washing, furnace-burden preparation and furnace operations for the production of elemental phosphorus.

Research Fellowship

A graduate fellowship of $1700 has been made available to Illinois Institute of Technology by Standard Oil Company (Indiana) for 1948-49 for "some chemical engineering field of general interest to the petroleum industry."

A similar fellowship was granted for the current year.

LaQue and Anderson Elected To Posts at NACE Meeting

Meeting in annual conference at St. Louis, more than 750 members of the National Association of Corrosion Engineers discussed the practical and theoretical aspects of corrosion control, mitigation and prevention. Ten symposia, dealing with as many different industrial contacts with the over-all problem of

LaQue

Anderson

corrosion, were covered during the technical sessions.

F. L. LaQue was elected president; H. H. Anderson, vice president; O. C. Mudd, treasurer; and the following directors: L. J. Gorman, representing active members; D. E. Stearns, representing associate members; and Vance N. Jenkins, representing corporate members. A. B. Campbell was continued as executive secretary.

LaQue is in charge of the Corrosion Engineering Section of the Development and Research Division, The International Nickel Company, Inc., New York. During the past year he served as vice president of NACE.

Anderson is vice president and general manager of Shell Pipe Line Corporation, Houston. He has served as a director of NACE for the past year. Mudd is chief corrosion engineer for Shell Pipe Line Corporation. He has served as treasurer since organization.

Gorman has been a member of the engineering staff of Consolidated Edison Company of New York and predecessor companies for 35 years. Since 1936 he has been engineer in charge of electrolysis and corrosion on underground cable and gas piping installations.

Stearns, who has his own company in Shreveport, La., formerly was associated with United Gas Pipe Line Corporation.

Jenkins has served as research chemists and supervisor for Union Oil Company of California for the past 15 years.

One of the papers presented was by Nathan Schofer and dealt with corrosion problems in a modern fluid catalytic cracking unit, containing very little alloy steel and its fractionating unit. Corrosion in the cracking unit is very low, largely because the hot vessels and lines are coated with carbon freed in the cracking process. Low temperature attack is prevented by the ammonia formed in the process. The fractionation system, which previously had only cooling water corrosion problems, became quite troublesome when the refinery began processing a small amount of high-sulfur crude oil. Carbon steel furnace and exchanger tubes failed in only a few months. Steel in several process vessels blistered and cracked and it is believed hydrogen penetration was responsible.

Ethyl Price Advance

The price of Ethyl anti-knock compound will be raised effective on shipments after June 30, according to advice by E. L. Shea, president of Ethyl Corporation, to customers in the United States and Canada.

This will be the first price change for tetraethyl lead since April, 1942. After June 30 the present price of 49.482 cents a pound for tetraethyl lead will be advanced to 54.98 cents a pound for the compound used in motor mix and 60.478 cents a pound for aviation mix.

All other conditions of sale will remain the same, Shea said. The upward revision in prices is due to "continued increases in costs." Lead, an important component of ethyl anti-knock compound rose 2½ cents a pound to 17½ cents several weeks ago.

Jersey Standard Reveals Extent of Research Effort

To help meet the increased demand for oil products and to continue studies for perfecting producing and refining methods, Standard Oil Company (New Jersey) spent more than $18 million in petroleum research in 1947. This research effort, carried out primarily through Standard Oil Development Company, represents an increase of about 18 percent over the previous year.

Jersey Standard's annual report shows that in a continuing study on the synthesis of oil from natural gas, coal, and oil shale, greatest emphasis so far has been placed on the conversion of natural gas to liquid products. The chief product is high quality gasoline, but substantial quantities of alcohols and other chemicals also are made.

"In this process," is was stated, "use is being made of the fluidized solids technique which the company developed just before the war for its method of catalytic cracking. Large-scale pilot plant operations during 1947 demonstrated the practicality of the process. research to improve the process further and to lower costs is continuing."

Economic studies indicate that production of liquid fuel from natural gas should be competitive in cost with production from crude petroleum, the statement said, adding that fuels from coal or oil shale will be more expensive, but not prohibitively so.

The company reported considerable progress in making oil from coal, this in cooperation with the Pittsburgh Consolidation Coal Company. Large pilot plant experiments will be carried out this year.

The fluidized solids technique appears also to offer a promising means of handling oil shale to recover its oil content.

As for improvement of refining methods, research currently is directed at lower costs for catalytic cracking, production of high octane gasoline from all fractions of petroleum, and increasing the yields of fuel oils of the home-heating and diesel type from the heaviest parts of crude.

Thomas Receives Medal

The American Institute of Chemists in New York, May 7 presented the Institute's gold medal to Dr. Charles Allen Thomas. Dr. Foster D. Snell, retiring president, who made the presentation

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explained it was not only for Dr. Thomas' work in the development of atomic energy and his leadership in research, but also for his administrative ability and his encouragement of basic research. Dr. Thomas is executive vice president and technical director of Monsanto Chemical Company and president of the American Chemical Society.

Rasbury With Sunray

A new department of industrial relations for Sunray Oil Corporation will be headed by James T. (Jim) Rasbury, formerly director of industrial relations for the Western Petroleum Refiners Association.

Rasbury will coordinate employe industrial relations activity for the company throughout all production and refining divisions. He began his duties with Sunray at Tulsa, April 15.

Test Service Centralized

With completion of its petroleum chemicals testing laboratory in St. Louis, Monsanto Chemical Company is prepared to offer a complete technical service, from usual chemical analyses to full-scale engine tests.

The laboratory houses the latest equipment, some of which had been in use at the company's previously scattered testing sites. Unusual feature is the central control hall, from which tests in surrounding engine cells may be controlled and observed.

Engine facilities include five Chevrolet test stands, two single cylinder Caterpillar diesel stands, and twelve Lauson single cylinder engines, used to screen-test for the larger engines.

Bennetts Succeeds Nolte At Grease Institute Post

Harry F. Bennetts has been named executive secretary of the National Lubricating Grease Institute to succeed Carl E. Nolte who had resigned to become vice president of the Battenfeld Grease and Oil Corporation, Kansas City, Mo. The national office will be retained at 4638 Mill Creek Parkway, Kansas City, Mo.

Bennetts

For the past four years Bennetts has served as executive manager of the Electric Association of Kansas City. He is a graduate of the School of Commerce of the Northwestern University where he majored in Finance. Bennetts has also attended the National Institute held by Northwestern University each summer for trade association and Chamber of Commerce executives. He has served as Technician in the laboratory of the Aluminum Company of America and has done considerable research and laboratory work in connection with his own business, which he sold in 1939.

Says Shale Is Most Likely Synthetic Fuel Oil Source

Production of petroleum from shale at present offers a logical approach to the problem of manufacturing synthetic gasoline and diesel fuel, R. M. Bartlett, vice president of Gulf Oil Corporation, said in an address last month. He described synthetic fuel research as urgent to conserve U. S. crude oil reserves and as insurance against the possibility of foreign supply being cut off by war.

Any break in our relationship with the Eastern nations, resulting in loss of Middle East crude oil, he asserted, "might immediately necessitate rationing, far deeper than ever before, if we attempted to still supply the countries to which we are committed under the European Recovery Plan."

Present world demand and production of oil are about equal, Bartlett said. But demand is steadily rising. To keep production up with this demand will require, he said:

1) Extensive development of pipe line and tanker transportation facilities for Middle East crude oil. 2) Building refineries in Europe to process crude from the Eastern Hemisphere, under ERP. (This aims at making Europe more self-sufficient in oil requirements). 3) Continued great exploratory efforts, particularly in South America. 4) Development of techniques for synthetic production of fuels as a protection against future emergencies.

At present, Bartlett said, production of synthetic fuel from natural gas has the disadvantage of losing about half the heat value of the gas in the process. Production of motor fuels from coal is more handicapped, dissipates about 60 per cent of the heat value of the coal. Plants for both processes are costly and would consume large quantities of steel.

Shale Development Logical

Bartlett pointed out that shale is not suitable for any other purpose; therefore, any fuel recovered from it represents a net addition to our national fuel resources, with no waste involved.

Present research projects into synthetic production of petroleum fuels will be completed in about three years. The building of commercial plants, Mr. Bartlett recommended, should be delayed until they can be considered in the light of the technological advances made in that period.

Meanwhile, to keep production up with the demand, Middle East transportation facilities must be rapidly expanded, Bartlett asserted. A tremendous pipe-line program is being launched but pending completion of these lines, additional tankers will have to be built.

Bartlett pointed to this advantage in the development of Middle East production:

"For each ton of steel used, from five to ten times as much oil can be produced in countries outside the United States as can be produced domestically. Middle East oil comes from comparatively shallow oil fields and there is a tremendous volume of oil per well, a 4000-barrel daily average against 12 barrels per well in the U. S."

Building refineries in Europe, Bartlett declared, "should decrease our need for refining and exporting gasoline and fuel oil to Europe. Even in 1948, it is expected that our exports will be about 20 percent less than last year."

Russia Said to be Lagging Behind U. S. In Volume Production of Synthetic Fuel

Russia is lagging behind the United States in the development of processes for the volume production of synthetic fuel, and has thrown up a special "iron curtain" around her scientific activities to hide that fact from the western world, Dr. V. I. Komarewsky, one of America's foremost experts on synthetic fuels, declared last month at Illinois Institute of Technology, Chicago.

"I have followed the progress of Soviet scientists in synthetic fuel production closely for over 15 years and I definitely feel that we are far ahead of Russia in the manufacture of synthetic petroleum from natural gas or coal," the Russian-born scientist asserted.

Dr. Komarowsky in 1936 organized a catalysis laboratory for research and educational purposes at Illinois Tech. In this laboratory he recently perfected new and simpler catalysts by which carbon monoxide and hydrogen can be combined chemically to produce 70-octane liquid hydrocarbons, artificial petroleum to supplement the nation's natural petroleum reserves. He is now working toward the improvement of gasoline product quality from this process.

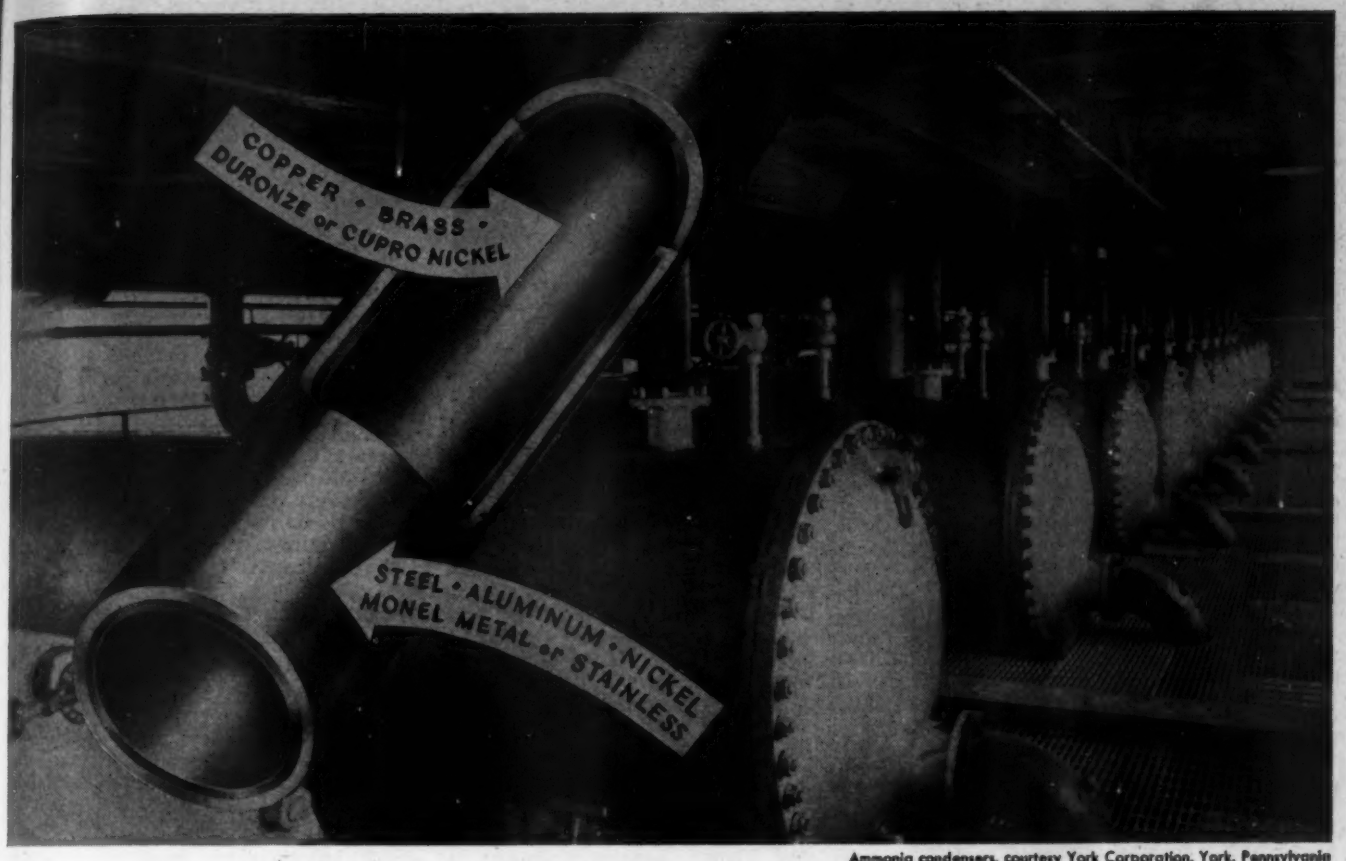
He made his announcement in connection with the transfer of the old historic catalysis laboratory to a new $965,000 Metallurgical and Chemical Engineering building.

"The Soviets are studying the catalysis processes that we are using but I don't think they have made much headway, chiefly because they haven't the reserve of skilled technicians and scientific instrumentalists that we have." He explained that the Russian government last year suddenly stopped the publication of all scientific journals destined for readers outside the USSR, including two important chemical publications in English which had been useful in the customary free exchange of experimental findings among the scientists of the world.

"However, we do know that the USSR is now devoting much of its attention to the low temperature carbonization process which can produce 80-octane gasoline from peat and brown coal, of which they have large stocks. But just how successful they have been is becoming harder and harder to determine," he emphasized.

New Employe Suggestion System Put Into Effect

Introduction of a new system to stimulate suggestions from its 41,000 employes has been announced by the Socony-Vacuum Oil Company, Inc. It removes ceilings on amounts which can be awarded to individuals for their ideas



Ammonia condensers, courtesy York Corporation, York, Pennsylvania

Reducing Corrosion in Refrigeration Systems

Refrigeration systems require many miles of tubing for handling corrosive liquids or gases. Consequently, selection of the most suitable corrosion-resistant alloy is of great importance.

For example, steel tubing in ammonia refrigeration systems has comparatively short life because it is attacked from the water side through excessive rusting, although it stands up nicely on the ammonia side. Much longer service life is obtained by using Bridgeport Duplex Tubing with steel to the ammonia side and copper or a copper-base alloy to the water or brine side. Also maintenance has been greatly reduced and heat transfer has been improved through Duplex Tubing.

Are you troubled with corrosion from one or more of these sources—(1) Refrigerant, (2) Brine, (3) Atmospheric, (4) Cooling water, (5) Product being cooled?

Excellent service has been obtained with the following gases and coolants by using the copper-base alloys indicated:

Ammonia—*Bridgeport Duplex Tubing, consisting of Copper or a copper-base alloy to the water side and steel to the ammonia side.*

Freon—*Copper, Aluminum Brass, Admiralty, 70-30 Cupro Nickel.*

Methyl Chloride—*in absence of moisture, all copper-base alloys . . . in presence of moisture, Silicon Bronze (632 and 609) and Red Brass.*

Methane, Butane, Propane, etc.—*all copper-base alloys.*

Fresh Water—*Copper, Red Brass and Admiralty.*

Sea Water—*Admiralty, Aluminum Brass, Duronze IV (aluminum bronze) and 70-30 Cupro Nickel.*

Bridgeport's corrosion laboratory can help you select the most suitable tubing alloy. Contact the nearest Bridgeport office. Write for Bridgeport's 120-page Condenser Tube Manual.

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CONDENSER AND HEAT EXCHANGER TUBING

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and establishes a uniform formula to assist in evaluating the suggestions.

Developed after nearly a year of intensive organizational effort and of surveys of several hundred suggestion systems in use elsewhere, the new Socony-Vacuum plan includes many features advocated by the National Association of Suggestion Systems.

Moran, Conoco Builder, Is Claimed by Death

Dan J. Moran, 60, former president of Continental Oil Company, died April 3 at Houston. Moran began his work in the oil industry with the Buckeye Pipeline Company. In 1908 he went to work for the Oklahoma Iron Works in Tulsa, designing and manufacturing standard and special drilling tools. He later became a petroleum engineer for the Texas Oil Company, immediate predecessor of The Texas Company. In 1921 when Texaco expanded in the Golden Lane of Mexico, Moran was made vice president, director, and manager of The Texas Company of Mexico and was called back to the states as vice president, director and member of the executive committee of the parent company.

Moran

In 1928 he left The Texas Company to become president of the old Marland Oil Company. A year later the company merged with The Continental Oil Company of Maine, and Moran, then 40, became president of the present Continental Oil Company. One of Moran's early achievements was building the Great Lakes Pipeline Company, the first large pipe line in the U. S. made to transport refined petroleum products. Lines were extended from Mid-Continent refineries to Kansas City, Omaha, Minneapolis, and Chicago. Under Moran's leadership, Continental became a major firm.

Moran retired as president of the company in 1947 because of failing health.

Norton H. Weber, 76, former vice president and director of The Pure Oil Company, died April 4 at an Evanston, Ill., hospital. He was a 61-year oil industry veteran. In tribute to Weber, a former president of the National Petroleum Association, Fayette B. Dow, general counsel of the NPA, placed him among "those who have done most to make the activities of the National Petroleum Association, during and after his presidency, successful expressions of industry cooperation."

Leon H. Marsh, vice president and secretary of The Kennedy Valve Manufacturing Company, Elmira, N. Y., died March 11, 1948. Marsh joined the company as traffic manager in 1918 and was appointed assistant sales manager one year later. He was named sales manager in 1941, became a vice president in 1945, and a director in 1947. Marsh served as director of the Valve Manufacturers Association in 1946 and 1947.

Hugo Frederick Urbauer, 79, founder and chairman of the board of Midwest Piping & Supply Company, Inc., of St. Louis, died on March 25, at Phoenix, Ariz. In 1899, he organized the Urbauer-Atwood Heating Company, and later formed the Midwest Piping & Supply Company, which has supplanted the original business.

While returning from Western Petroleum Refiners Association's annual meeting at Galveston, **Roy E. Curran,** 55, president of Suburban Oil Company, Oak Park, Ill., died of a heart attack in Dallas on April 8, 1948.

John Britton Named Head Of Enjay Company, Inc.

John A. Britton, Jr. has been named president of Enjay Company, Inc., chemical products marketing affiliate of Esso Standard Oil Company, succeeding H. W. Fisher. O. V. Tracy, assistant manager of Esso Standard's Chemical Products Department, has been elected a director of Enjay, succeeding Dr. H. G. Burks, Jr.

Tracy

Britton

Britton became a vice president of Enjay upon its organization in 1947, previously being associated with Standard Oil Company (New Jersey) and affiliated companies for 27 years.

Tracy joined the research department of Standard Oil Company of Louisiana at Baton Rouge in 1930.

H. W. Fisher, general manager of East Coast Manufacturing and manager of the Chemical Products Department of Esso Standard Oil Company, will continue to serve as director of Enjay.

NGSMA Elects

Roy R. Bush, Nordstrom Valve Company, was elected president of the Natural Gasoline Supply Men's Association (NGSMA) at the annual convention of the NGAA in Fort Worth. J. N. McClure, Elliott Company, was elected first vice president; L. L. Dresser, Dresser Engineering Company, second vice president, and Dallas S. Deems, American Air Filter Company, Inc., treasurer. William F. Lowe was reelected secretary.

The NGSMA was host to members of the NGAA at the annual banquet and show.

Gordon Appointed

David Gordon, 29 Broadway, New York, has been appointed by the Process Industries Division of the American Society of Mechanical Engineers to act as its liaison officer with the American Institute of Chemical Engineers and the American Chemical Society.

Record Run

The Co-operative Refinery Association recently completed a record run at its Coffeyville, Kan., refinery. During 164 on-stream days 720,000 barrels of crude was processed by the 4200-barrel-a-day two-coil thermal cracking unit.

Research Grant

The Research Corporation of New York has made a grant of $1800 to chemical engineering department at Washington University, St. Louis, to support a year's study on solvent extraction.

Record Activity Noted in Refining Circles of France as Plants Expand

E. N. TIRATSOO, London

In 1938, the French refining industry produced 44,733,000 barrels of refined products. Then there were 15 major refineries which had been constructed during the period of 1925 and 1928 at a cost in excess of a billion dollars. Crude oil processed in these refineries was imported mainly from Iraq (38 percent), the United States (34 percent), and South America (20 percent).

In 1944, war destruction and deterioation resulted in a large reduction in refining capacity, the over-all throughput being approximately 8,800,000 barrels. Of the original major refineries, only three were intact, nine were severely damaged and three of the principal plants had been completely destroyed.

After the end of hostilities an intensive program of construction and rehabilitation was undertaken. By 1947's end, 12 refineries were back in operation and their capacities reflected a yearly output of 50.8 million barrels. This was about 75 percent of the total French and Algerian requirements. Further increase of output is unlikely in the near future due to the shortage of steel and the fact that payment by the French government of only 2 percent of the 40,000 million francs war damage suffered by the industry has been made.

By 1955, according to the Monnet Plan, French domestic requirements are expected to exceed 111 million barrels. The French refining industry is planning to process 75 percent of this requirement from crude imported from the Middle East.

In view of the utilization of the Middle East crude a majority of the expansion of the French refining industry is planned for the Mediterranean area where the yearly capacity would aggregate 30,710,000 barrels.

A refinery in the north of France is planned with a yearly capacity of 10,360,000 barrels. A group of refineries

THE MONTH . . .

planned for the Lower Seine area will process yearly 42,180,000 barrels and two are planned for the Atlantic area with a capacity of 12,500,000 barrels yearly.

In addition, the Pechelbronn refinery at Merkwiller will process approximately 1,036,000 barrels of domestic crude making the over-all potential yearly capacity of the French refining industry 96.2 million barrels.

Mergers for Efficiency

As a result of the program of concentration outlined in the Monnet Plan, a number of refineries have already been merged for greater efficiency. The prewar number of 15 major refineries has been reduced to a total of 12. The Raffinerie de Berre and the Shell subsidiary, S. A. des Petroles Jupiter have been merged to form a new company, Compagnie de Raffinage Shell-Barre. This company plans extensive installations with a plant planned for the Mediterranean coast with a capacity of 11.1 million barrels annually.

Another instance of concentration is the agreement concluded between the Societe Generale des Huiles de Petrole and the Raffinerie de Petrole du Nord. It is expected that the decision of the French government to transfer all rights to import crude petroleum from the latter to the former company will considerably increase refinery activities in the north of France. The Societe Generale des Huiles de Petrole will erect a refinery at Dunkirk with an annual capacity of 7.4 million barrels and the Courchelette refinery owned by the same company will concentrate on the processing of lubricating oils. Finished products will be divided between the Societe Generale des Huiles de Petrole and the Raffinerie de Petrole du Nord, the latter making its own independent allocations.

It is believed that this arrangement will go a long way toward assuring France of "sterling crude oil" in view of the ties between the Societe Generale des Huiles de Petrole and Anglo-Iranian Oil Company.

Another recent merger is the French petroleum industry carried out in execution of the Monnet Plan is that of the Donges refinery, belonging to the Pechelbronn-Ouest Ltd., with the Les Consommateurs de Petrole also of Donges. The Raffineries Francaises de Petrole de L'Atlantique at Donges, formed as a result of this merger will have an annual capacity of 5,920,000 barrels as against the 2,220,000 barrels annual capacity of each of the separate companies.

A further possible merger of the French subsidiary of Standard Oil Company (New Jersey) the Standard Francaise des Petroles and of the French company Compagnie Generale des Petroles pour l'Eclairage et l'Industrie also is under consideration.

Construction Speeded Up

The California Texas Oil Company has taken steps to speed the construction of two refineries in France and Holland for its European affiliates. Preliminary work has been started on the reconstruction of a refinery near Bordeau belonging to Raffineries de Petroles de la Gironde which had been out of operation since 1940. When complete in 1950, the plant will have sufficient capacity to produce 14,000 barrels daily of refined products for distribution in southwestern France. Prewar capacity of this plant was 8000 barrels a day.

A further development of interest is the 20-year agreement recently concluded between the Compagnie Francaise des Petroles and the Italian Aprideliom group whereby the French company is to have a 30 percent interest in a development scheme for the refining and distribution of petroleum at Genoa. The Compagnie Francaise des Petroles will supply Italy with 4,440,000 barrels of crude oil and petroleum products which it is believed will be of Iraq origin.

Salt Lake City Refinery Construction Is Speeded

Details of plans to speed construction of the crude oil pipe line from Rangely, Colo., and the new refinery in Salt Lake City were revealed last month by C. E. Finney, Jr., recently elected president of both Salt Lake Refining Company and Salt Lake Pipe Line Company. The refinery likely will be "on stream" by November. Grading and fill for the main refinery installation already has been completed and a contract is scheduled to be awarded shortly for the general fill job.

Bechtel Corporation will build the main installation, consisting of a crude distillation unit, necessary boiler capacity and pipe lines connecting the tanks, racks and processing units. Tankage, with a storage capacity of more than 500,000 barrels will be constructed by the Chicago Bridge and Iron Company. A subcontract has been awarded to the Lang Company of Salt Lake City for fabricating columns, the main stack and some tanks and vessels.

A prime contract has been awarded Morrison-Knudsen Company of Boise, Idaho, for construction of refinery buildings, including office and laboratory, locker and shop units.

Future expansion of the refinery will depend on developments, Finney said. The present unit, to cost more than $5 million, is regarded as the initial step of a long-range refinery program to serve the Intermountain region.

Shell and California Plan Big New Jersey Refineries

Refinery building and expansion plans amounting to a total of about $125 million by Shell Oil Company, Inc., and California Refining Company in New Jersey have been disclosed.

Woodbridge, New Jersey, is the possible site for construction of a Shell refinery and Perth Amboy the site of California Refining Company's unit, formerly the Barber Asphalt Corporation plant.

The Shell refinery will cost about $100 million and the California Refining Company expansion program, $25 million.

Sun to Double Capacity Of Its Toledo Refinery

Expansion of Sun Oil Company's Toledo refiinery over the next two years at a cost of $16 million was announced last month. The proposed expansion includes construction of an approximate 30,000 barrel-a-day catalytic cracking plant, a crude distillation unit, a vacuum unit, a large gas recovery plant, a new polymerization plant and auxiliary units.

The proposed expansion will constitute a complete refinery in itself and upon its completion the capacity of the present refinery will be almost doubled. Clearing of the site for the new installations will commence about June 1 and it is hoped the major construction work can be completed by the end of next year.

When the job is done, Sun's Toledo refinery "will rank among the 20 largest refineries in the country and few will exceed it in catalytic cracking capacity," Vice President Clarence H. Thayer declared.

Phillips Chemical Would Expand Around Houston

Phillips Petroleum Company will spend $6 to $10 million for an expansion program in the Houston, Texas, area if the Phillips bid to lease the government-owned Etter, Teaxs, ammonia plant is accepted, according to K. S. Adams, Sr., president of Phillips.

Phillips would build one or two ammonia sulphate plants on the Houston ship channel on a 300-acre tract of land already purchased. In addition, the plans include a gasoline plant in the Chocolate Bayou field (planned a year ago), a large housing project at Sweeny, Texas, and 165-mile crude oil line from Corpus Christi, Texas. The chemical plants would be handled under Phillips Chemical Company, Adams said.

Plans are also underway to enlarge the company's Old Ocean plant at Sweeny from 35,000 barrels per day to 45,000 barrels per day.

Definite announcement could not be made of the projects until a later date, Adams said late in April.

Refinery Expansion Shown By Pennsylvania Survey

More than $121,097,000 will have been invested since the war in new plants and equipment in Pennsylvania by 15 petroleum refining companies, Governor James H. Duff revealed last month. The survey, containing actual figures on construction for 1946 and 1947, and estimates for 1948, also showed a total of $45,364,893 by 39 chemical and chemical products companies.

Haifa Refinery Expansion Is of Immense Proportions

Consolidated Refineries, Ltd., Haifa, Palestine, if and when its expansion is completed, expect to be in a position to refine in excess of 48 million barrels of Middle East crude oil annually upon completion of their present expansion program. Completion was scheduled for late 1949. Process equipment is being fabricated by British concerns from design specifications supplied by various American engineering firms.

The construction program, likely halted by present hostilities, includes a complete lubricating oil processing unit with a capacity of 2000 barrels daily of finished products; a furfural unit, a MEK dewaxing unit, and a clay contacting unit, all designed by The Lummus Company; crude and vacuum distillation

units having a daily capacity of over 80,000 barrels, designed by E. B. Badger and Sons; and a propane de-asphalting unit designed by The M. W. Kellogg Company.

Richfield Plant Enlarged

Completion of facilities to increase the process capacity of the North Coles Levee absorption plant in Kern County, California, by 40,000 mcf. and the addition of 2400 horsepower, to its pressure maintenance plant have been announced by Richfield Oil Corporation, Los Angeles. Total cost of the two projects amounted to about $2,005,000. Process work was contracted to C. F. Braun and Company, and the pressure maintenance work to The Fluor Corporation.

Refinery for Venezuela

Sinclair Oil Corporation will build a 35,000-barrel-a-day refinery at Puerto La Cruz, Venezuela, for the Venezuelan Petroleum Company, a Sinclair affiliate.

Preliminary work is under way with completion of the refinery scheduled for 1951.

Skelly Enlarging Plant

Installation of a 30,000-barrel-per-day crude distillation unit and a catalytic cracking unit will complete the enlargement and modernization plan of Skelly Oil Company at its El Dorado, Ark., plant. The new units will provide a complete 30,000-barrel-per-day refinery. Construction is expected to be completed by January, 1950.

Benton Heads Root

Dwight F. Benton has been elected president of Root Petroleum Company; H. Canon, R. L. Aycock, and Joe Hyer vice presidents; T. E. Beaird, secretary; and A. L. Reid, treasurer.

A retirement plan for benefit of company officers and employes was approved by the stockholders.

Haugen Named Construction Head by Stanolind Company

Lawrence T. Haugen has been appointed construction superintendent of Stanolind Oil & Gas Company's manufacturing department. He formerly was a captain in the U. S. Navy, being a graduate of the U. S. Naval Academy. He has an M.S. degree in naval construction from Massachusetts Institute of Technology.

Haugen

With headquarters in Tulsa, Haugen will supervise Stanolind's plant construction program, which includes: the synthesis project at Garden City, Kan., which will include a natural gasoline plant, an oxygen plant, the synthesis unit itself, and a chemical refining plant; a chemical products plant at Brownsville, Texas, to refine the chemical stream from the Carthage Hydrocol, Inc., synthetic gasoline plant; and six natural gasoline and cycling plants.

It is probable that construction of several more gasoline plants will be authorized within the year, officials said.

Oil Man Is Honored by SAE

Some 300 engineers and industrialists, including many oil industry representatives, joined in the recent testimonial dinner at Pittsburgh for Reginald J. S. Pigott, in charge of engineering research for the Gulf Oil companies and the first oil man to be named president of the Society of Automotive Engineers. At the speaker's lectern (above) Colonel J. Frank Drake, president of Gulf, hailed Pigott's election as "an honor to him and to the oil industry." Seated, left to right, are Pigott, Wallace Hallam, chairman of the Pittsburgh Section, SAE, which sponsored the dinner, and John M. Orr, past Section chairman. Principal address was delivered by Arch T. Colwell, vice president of Thompson Products, Inc., who discussed future trends in motor vehicles. An overflow crowd took part in the testimonial.

Esso Standard Names Ulrope

L. E. Ulrope has been named vice president and director in charge of marketing of Esso Standard Oil Company, and E. H. Collins, previously manager of wholesale marketing, appointed general manager of the marketing department succeeding Ulrope. B. L. Ray and G. W. Poorman were named managers of direct and wholesale marketing, respectively.

Record Run at Allen

The three-furnace thermal cracking unit at Sunray Oil Corporation's refinery at Allen, Okla., last month was shut down for inspection and clean out after having established the longest continuous run on record (170 days, 22 hours) for a Dubbs thermal cracking unit, F. L. Martin, executive vice president, said. The cracking unit charged an average of 8037 barrels daily against a rated daily cracking capacity of 7000 barrels. A. D. Vinson is superintendent of Sunray's Allen refinery, and T. L. Tiernan, assistant.

Oil Experiment Plan

The House Public Lands Subcommittee has unanimously approved a bill calling for construction and operation of a $1 million experimental station in the Appalachian region for research in production, refining, transportation, and uses of natural gas and oil.

The House Public Lands full committee will act upon the bill shortly and upon approval the bill will carry an annual appropriation of $500,000.

Texaco Changes

Personnel changes in the Los Angeles area in gasoline operations of The Texas Company include: G. W. McCredie, former field foreman, who has been with the company 27 years, has retired; C. A. Perry, former gas dispatcher, has taken over the duties of field foreman; Geo. H. Forster, Jr., former head field tester, is now gas dispatcher, and Thos. F. Smith, former utility relief, is head field tester.

Malco Leases Gratex

Malco Refineries, Inc., of Roswell, N. M., have acquired a three-year lease of Gratex Refining Company's 500-barrel-a-day refinery at Graham, Texas.

E. R. Marchman, Gratex general manager, said terms of the lease include an option to buy the refinery. The lease also includes a crude exchange agreement wherein Gratex will maintain its bulk plants and stations which will be supplied by Malco.

Ghormley With Armistead

Edward L. Ghormley, formerly of California Research Corporation, has joined the staff of George Armistead, Jr., Consulting Chemical Engineer of Washington, D. C. Ghormley, who has recently completed graduate work at Massachusetts Institute of Technology will be engaged in process and design engineering.

Ghormley

The Armistead offices are maintained at 1200 Eighteenth Street, Washington 6.

SCIENCE *and* TECHNOLOGY ABSTRACTS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

prepared in cooperation with
Petroleum Refiner* by *The Leslie Laboratories
Traver Road, Ann Arbor, Michigan, under supervision of
DR. E. H. LESLIE and DR. H. B. COATS

Fundamental Physical and Chemical Data

Heat and the External Work of Vaporization of Twenty-two Hydrocarbons. J. E. HAGGENMACHER, *Ind. Eng. Chem.* **40** (1948) pp. 436-7.

A method of calculation is given for the heat and external work of vaporization from vapor pressure data. The external work of vaporization was calculated for 22 hydrocarbons whose critical pressure and critical temperature were available. Success of the method depends on the quality of the vapor pressure data and very much upon the rate of change of vapor pressure derived therefrom. Equations of calculated values and precise measurements show deviations up to a few tenths of one percent. A bibliography of 21 references is included, and detailed results of the calculations are given in tabular form.

Measurements of Heat of Vaporization and Heat Capacity of a Number of Hydrocarbons. NATHAN S. OSBORNE AND DEFOE C. GINNINGS, *J. Research Natl. Bur. Standards* **39** (1947) pp. 453-77.

Using a new small calorimeter, accurate measurements were made of the heat capacities of 12 hydrocarbons in the range 5 to 45° C. and the heats of vaporization of 59 hydrocarbons at 25° C. Measurements of the heat capacity before, during and after the series of hydrocarbon experiments were in good agreement with those of an earlier calorimeter, as were the measurements of heat capacity of n-heptane. The values obtained in the work are presented in detail.

Determination of Ignition Temperatures of Combustible Liquids and Gases. G. S. SCOTT, G. W. JONES AND F. E. SCOTT, *Analytical Chem.* **20** (1948) pp. 238-41.

Apparatus is described, for the determination of the minimum ignition temperatures of liquids and gases by the drop method, comprising a stainless steel block, heated electrically and containing a 125-cc. pyrex glass flask in the center. Gases are liquefied by means of dry ice or liquid nitrogen before testing. Lower minimum ignition temperatures are obtained with this apparatus than with those using liquid baths because of a closer approach to black body conditions. A tabular comparison is given showing ignition temperatures obtained in the steel bath and in the usual nitrate bath. Minimum ignition temperatures of 172 gases and liquids are given in tabular form for ignition in air and also in oxygen. A bibliography of 40 references is included.

Thermodynamic Characteristics of the Equilibrium I-Butene $\rightleftarrows$ 1,3-Butadiene + H_2. J. C. GHOSH AND S. RAMA DAS GUHA, *Current Sci.* (India) **16** (1947) p. 252.

On the basis of Aston's most recent data on the specific heat of butene and butadiene, the free energy change for the reaction 1-butene $\rightleftarrows$ 1,3-butadiene + H_2 was recalculated. The new values are $\Delta F_T = 25{,}612 - 6.256T \ln T + 0.001367\ T^2 + 0.00000041\ T^3 + 16.05\ T$, and $\Delta F_{298} = 19{,}884$, $\Delta H_{298} = 27{,}334$, and $\Delta S_{298} = 25.0$.

Composition and Boiling Points of Binary Azeotropes. H. P. MEISSNER AND S. H. GREENFELD, *Ind. Eng. Chem.* **40** (1948) pp. 438-41.

The literature of the subject of azeotropes is briefly reviewed. The object of the present paper is to present empiracle correlations for predicting the compositions and boiling temperatures of homogeneous binary azeotropes in which one component is always a hydrocarbon or a halogenated hydrocarbon and the other component is an alcohol, carboxylic acid, aldehyde, ketone, phenol, or cresol. Esters are also considered as second components. Since all hydrocarbons and most chlorinated hydrocarbon azeotropes are of minimum boiling type, the correlations presented are limited to this classification. Two figures are given showing the proposed relations for obtaining the composition of a homogeneous binary azeotrope, and one figure is given that can be used in predicting the atmospheric boiling temperatures.

Correlation of Azeotropic Data. HERMAN SKOLNIK, *Ind. Eng. Chem.* **40** (1948) pp. 442-53.

The author briefly discusses the several empirical methods that have been employed for the analysis and interpretation of azeotropic systems. The disadvantages of these methods are indicated. The paper describes a new method based on the relation between a) the azeotrope boiling point and the logarithm of the azeotropes composition; b) the azeotrope boiling point and the boiling point of the pure components of the azeotrope; and c) the boiling points of the pure components of the azeotrope and the logarithm of the azeotrope composition. Relations a and b are straight-line functions from which relation c is derivable. The three relations are employed for the correlation of the azeotropic data of the systems: benzene-saturated hydrocarbons, benzene-alcohols, and ethanol-hydrocarbons. Interpolations can be made on the straight-line relations a and b that permit predictions of azeotropic behavior with more certainty than previous methods. The term "relative azeotropic effect" is introduced as a measure of the azeotropic effect of an azeotropic agent in various systems compared to the azeotropic effect of benzene on saturated hydrocarbons.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has reecived urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

p-tert.Butyl-o-cresol
5-Methyl isophthalic acid
4-Nonynoic acid
4-Nonenoic acid
2-Bromo-4-butylglutaric acid
trans-1-Cyclopentyl-2-butene
trans-4-Cyclohexyl-2-pentene
trans-4-Cyclohexyl-1-2-heptene
Cyclohexylalkyl ethylenes
1-Vinylcyclohexene-1
1-Vinylcyclohexadiene-1,3
1-Vinylcyclopentene-1
1-Vinylcyclopentadiene-1,3
Quinitol
Vinyl naphthalenes
2,3- or 4-Vinyldiphenyl
1- or 2-Vinylanthracene
Vinyl cyclohexane
Vinyl cyclopentane
Hexadiene-1,3
1-Chlorobutene-2

Chemical Composition and Reactions

Some Catalytic Hydrogen Exchange Reactions of Hydrocarbons. J. AMAN, L. FARKAS AND A. FARKAS, *Jour. Am. Chem. Soc.* **70** (1948) pp. 727-32.

The following exchange reactions of hydrogen atoms on palladium and nickel catalysts at pressures of 20-700 mm. and in the temperature range of 80-170° C. were studied: water and ethylene, water and butene, water and butane, butene and thylene and butane and ethylene. It was found that exchange of hydro-

gen atoms between ethylene and water, butene and water and butene and ethylene occurs, while under the same experimental conditions no exchange between butane and water or butane and ethylene was observed. The results are discussed and the importance of the mutual displacement of the reactants on the catalyst surface is emphasized. Two mechanisms for the exchange reactions were discussed in the light of the new experimental evidence. The negative result of the exchange experiment with ethylene and butane is presumably caused by the displacement of the butane from the surface of the catalyst by ethylene.

Pyrolysis of High Polymeric Hydrocarbons. RAYMOND B. SEYMOUR, *Ind. Eng. Chem.* **40** (1948) pp. 542-27.

The stability of high polymeric hydrocarbons toward depolymerization as determined by the lowest temperature at which volatile products are produced was shown to be as follows: polyethylene > polystyrene > polyisobutylene. A mechanism of the depolymerization is presented in which the role of free radicals is emphasized. The type of decomposition products obtained in the pyrolysis of polymeric hydrocarbons is shown to be a function of the structure of the hydrocarbon chain and the volatility of the products of pyrolysis. A bibliography shows 16 references.

The Electrolyte Effects in the Hydration of Isobutene. FRANK G. CIAPETTA AND MARTIN KILPATRICK, *Jour. Am. Chem. Soc.* **70** (1948) pp. 639-46.

The rate of hydration of isobutene in aqueous solutions of perchloric, p-toluenesulfonic, hydrochloric and trichloroacetic acids was investigated by the dilatometric method. The electrolyte effects of the strong acids on the rate of the reaction are greater than predicted by the theory of primary salt effects. Trichloroacetic acid solutions observed velocity constants appear to be greater than would be expected on the basis that the reaction is catalyzed solely by hydrogen ion. However, the results obtained in dichloroacetate and monochloroacetate buffer solutions do not indicate any basic catalysis of the cation of isobutene or catalysis by the molecular acid. The dissociation constants of trichloro- and dichloroacetic acids were calculated from kinetic measurements.

The Polymerization to Lubricating Oils of n-Heptene-1 and n-Pentadecene-1. G. H. DAZELEY AND C. C. HALL, *Jour. Soc. Chem. Ind.* **67** (1948) pp. 22-3.

It was found when studying the aluminimum chloride polymerization to lubricating oils of the product of thermal cracking that the higher fractions (bp. over 170° C.) gave oils of lower oxidation number than the lower boiling product. For the most part the studies of olefin polymerization have been restricted to olefins of short chain-length, and in no case has the oxidation stability of the resulting oils by an accepted test, such as that of the Air Ministry, been reported. Since olefin-polymer oils usually fail to meet the requirements for high-grade aviation oils only in respect of their oxidation stability, this has been a notable omission. The investigation reported in the present paper was undertaken to determine for one type of olefin whether increase in chain length was accompanied by an increase in oxidation stability of the olefin-polymer oil. It was concluded that the oxidation stability of olefin-polymer lubricating oils is independent of the chain length of the original olefin. It was found that the viscosity index of oils made from pure normal alpha-olefins is higher than that of oils made from cracked olefins of similar chain length. The viscosity index increases with increase in olefin chain-length and for the C_{18}- -olefin has a value of 130. A bibliography shows nine references.

Higher Hydrocarbons. V. Alkyl Anthracenes and Alkyl Phenanthrenes. ROBERT W. SCHIESSLER, ANTON W. RYTINA AND FRANK C. WHITMORE, *Jour. Am. Chem. Soc.* **70** (1948) pp. 529-30.

The methods of preparation, yields, and five important properties are given for two alkyl anthracenes, one alkyl phenanthrene, and the corresponding perhydro derivatives. The aromatic hydrocarbons are pure, but the perhydro derivatives are known to be mixtures of cis-trans isomers. Data on the preparation, yields and properties of six intermediates are also given. Melting points, boiling points, densities, viscosities, refractive index and molecular refractions are tabulated.

Manufacture: Processes and Plant

Heat Transfer to Gases Through Packed Tubes. MAX LEVA AND MILTON GRUMMER, *Ind. Eng. Chem.* **40** (1948) pp. 415-19.

The authors refer to an equation previously given by them for the correlation of heat transfer data in packed tubes. In this equation h is not shown in relation to packing characteristics such as uniformity, shape, thermal conductivity and surface roughness. The effect of these factors has been studied. It was found that equation applies to mixed packings provided the arithmetic-average diameter is chosen. For Raschig rings, the nominal size can be used as the diameter. For cylinders an equivalent spherical diameter on a volume basis must be used. The heat transfer coefficient increases for increasing thermal conductivity of the packing, and a relation was developed showing h as a function of k. Surface roughness influences the magnitude of h slightly, the rougher particles giving somewhat higher heat transfer coefficients. A possible mechanism of heat flow through the core of packed tubes is considered.

Catalytic Dehydrogenation of Normal Butenes to Butadiene in the Presence of Steam. L. H. BECKBERGER AND K. M. WATSON, *Chem. Eng. Progress* **44** (1948) pp. 229-48.

A small pilot plant was designed and constructed for kinetic studies of the catalytic production of butadiene by dehydrogenation of normal butenes in an atmosphere of steam over the "1707" catalyst of Standard Oil Development Company. Rates of the principal primary and secondary reactions, both catalytic and noncatalytic, were established over considerable ranges of conditions. Equations are presented relating these individual reaction rates to the controlling conditions. It was found that the kinetics of the primary catalytic dehydrogenation reaction is consistent with a mechanism assuming the reaction of an adsorbed n-butene molecule with an adjacent vacant active center. The most important secondary reaction at commercial operating conditions was the catalytic cracking of butadiene. A method is given for the simultaneous integration of the rate equations to predict the performance of commercial scale reactors. Results obtained by use of this equation are in close agreement with the performance of operating plants. The data are presented in graphical form and a bibliography includes 15 refeernces.

Evaluation of Catalysts for Catalytic Cracking. A. R. RESCORLA, J. H. OTTENWELLER AND R. S. FREEMAN, *Anal. Chem.* **20** (1948) pp. 196-202.

Catalyst activities can be estimated by surface area tests, such as aromatic adsorption or nitrogen adsorption. Several procedures for direct determination of catalyst activities in laboratory units are described and discussed. Chemical analysis of the catalyst indicates possible contamination. However, information on the various physical properties of the catalyst is essential to efficient operation of the catalytic unit. It is possible that future analyses on cracking catalysts will include a more detailed analysis of the metals present in the catalysts. No doubt the present laboratory cracking procedures will be standardized to allow a better interpretation of the results. Use of surface area measurements may become more widely accepted. A bibliography of eight references is included.

Reactor Design for Manufacture of Toluene by Catalytic Reforming. A. A. BURTON, E. B. CHISWELL, W. H. CLAUSSEN, C. S. HUEY AND J. F. SENGER, *Chem. Eng. Progress* **44** (1948) pp. 195-200.

The process used for the manufacture of toluene comprises catalytically reforming a 180 to 230° F. cut from California crude over molybdena-alumina catalyst in the presence of recycle hydrogen. The total pressure is 200 psig. with the catalyst inlet temperature approximately 1000° F. The catalyst selected was superior because of activity for toluene production from C_7 napthenes, and for a stability at high temperature. The Richmond plant operated for more than two years on a single charge of catalyst. The article contains data on the nature of the feed stock, on pilot plant operations, on the regeneration of feed catalyst, on the operating cycle and on the design conditions. Although the transition from comparatively small apparatus to full-scale equipment was a large step, the design of the reactors proved eminently satisfactory.

Jet-Type Reactor Alkylation Unit. ERNEST W. BOWERMAN AND BRYSON M. FILBERT, *Ind. Eng. Chem.* **40** (1948) pp. 542-4.

The small alkylation plant described was designed and used primarily for the evaluation of certain refinery olefinic stocks as feed components to a large scale alkylation plant. The evaluation required the determination of the yield and quality of the alkylate that could be produced by condensing the olefin

with isobutane in the presence of sulfuric acid catalyst, the measurement of the rate of catalyst degradation and the development of sufficient information on the effect of operating conditions to ascertain whether or not the stock in question could be processed in the plant equipment. The procedure of evaluation is described as well as the details of the operation. The data obtained showed that a C_3 stock produced by catalytic cracking was a better alkylation feed than a stock produced by thermal cracking.

Fluidization of Solid Particles. RICHARD H. WILHELM AND MOOSON KWAUK, *Chem. Eng. Progress* **44** (1948) pp. 201-18.

The authors report experiments on the fluidization of solid particles by means of air and water in 3-inch and 6-inch diameter columns. Spherical and uniformly sized particles of sand, glass, silicate catalyst, and lead shot ranging in size from 5 mm. to 0.3 mm. in diameter, and in density from 1.25 to 10.792 g./cc. were used. Qualitative observations were made with 100 to 200-mesh catalyst material and other fine powders. Pressure drop, fraction void, and velocity were measured and are correlated in generalized terms through four dimensionless groups, which are given. Two modes of fluidization, termed particulate and aggregative fluidization, are described and discussed. An analogy between these types of fluidization and the behavior of true gases and liquids is suggested. Detailed data are presented in 28 tables and 17 figures. A bibliography of 20 references is included.

Avoiding Destructive Velocity through Adsorbent Beds. EDWARD LEDOUX, *Chem. Eng.* 55 (1948) pp. 118-19.

In industrial adsorption plants, excessive adsorbent consumption is often directly traceable to excessive velocity of gas flow. The effect is most pronounced in the top layers of the bed where the granules are subject to less pressure from the layers above them. Continual churning of the adsorbent results in powdering by abrasive action and the entrainment of the fine material into the gas stream. To avoid trouble in operation the mass velocity must be kept below a maximum value that depends upon several factors. A dimensionless expression is derived for the maximum space gas velocity that can be used as a guide in the design of systems for various gases, different adsorbents, at different pressure an dtemperature conditions.

Metallurgical Methods for Comating Corrosion and Abrasion in the Petroleum Industry. D. B. MORTON, *Jour. Inst. of Petroleum* **34** (1948) pp. 1-68.

The author reviews steps that have been taken in the petroleum industry to counteract destruction from corrosion and abrasion. The subject was first discussed with reference to production and transportation and following that in connection with refining. Materials for use at low temperatures are considered and the value of nickel as an alloying element is shown. The next section of the paper deals with protection of equipment in the intermediate temperature range 0 to 500° F. The subject of vessel linings is discussed at some length. Condensers are next considered. In the majority of cases Admiralty tubing is used and when corrosion is severe 70-30 copper-nickel tubes are now used extensively. Materials for refinery pumps are briefly considered. In general, with respect to corrosion in refineries, it has been found that above 500° F. sulphur attack is the source of major corrosion and is best resisted by chromium-containing alloys. Below 500° F. corrosion is largely electrolytic in nature and is best resisted by the non-ferrous materials. One of the best alloy steels is Type 316 containing 2 percent of molybdenum. This resists organic acids, sulphur dioxide, weak mineral acid, sulphur attacks and sea water to a satisfactory degree. Various corroding substances are discussed, including sulphuric acid, hydrochloric acid, caustic soda, phosphoric acid, hydrofluoric acid, naphthenic acids, solvents such as furfural, phenol, ethanolamine, and the chlorinated solvents. A large section of the paper deals with corrosion within the temperature range 500° to 1300° F. Oxidation of the metal becomes a factor at these higher temperatures and sulphur and some naphthenic acids attack certain metals actively. The high temperature region 1300-2000° F. is also considered. In this temperature range sulphur and caustic are particularly active and harmful. The high temperature strength of metals is briefly reviewed. A bibliography shows 18 references.

New Hydrocarbon Samples Are Offered by Bureau

Through a cooperative program of the National Bureau of Standards and the American Petroleum Institute, 139 compounds are now available as NBS standard samples of hydrocarbons for calibrating analytical instruments and apparatus in the research, development, and analytical laboratories. The program meets industry's urgent need for standards of high purity for calibration of spectrometers. The most recent additions to the series of compounds, announced by the bureau over the past six months, are listed below (each unit 5 ml [liquid] in volume and each priced at $35 per unit except 513-5S, $25).

NBS Sample Number[a]	Compound	Amount of Impurity[b]
		Mole percent
541-5S	2,2,3-Trimethylhexane	(0.30±0.20)[c]
544-5S	3,3,4-Trimethylhexane	0.23±0.10
270-5S	cis-1,3-Dimethylcyclopentane	0.65±0.23
530-5S	2-Methyl-1-pentene	0.19±0.09
532-5S	4-Methyl-1-pentene	0.18±0.12
547-5S	4,4-Dimethyl-1-pentene	0.15±0.08
550-5S	2,3,3-Trimethyl-1-butene	0.06±0.04
548-5S	trans-4-Octene	0.16±0.11
551-5S	1-Nonene	0.24±0.18
552-5S	1-Decene	0.11±0.07
513-5S	1,3-Butadiene	(0.08±0.04)[d]
549-5S	2-Methyl-1,3-butadiene (Isoprene)	(0.04±0.03)[d]
553-5S	1,5-Hexadiene	0.11±0.08

Tolerance approximately ±10 percent in volume.

[a] The designation "-5S" following the sample number indicates a sample of 5 ml sealed "in vacuum" in a special Pyrex glass ampoule with internal "break-off" tip.

[b] The purity has been evaluated from measurements of freezing points, as described in J. Research Natl. Bur. Standards 35, 355 (1945) RP1676; unless otherwise indicated.

[c] Estimated by anology with isomers subjected to similar purification.

[d] When sealed. Polymer formed may be removed as residue by simple vaporization of the sample "in vacuum" at an appropriate temperature.

Instructions for transferring standard sample of hydrocarbons "in vacuum" are available on request. A complete list of NBS standard samples of hydrocarbons may be obtained from the National Bureau of Standards, Washington 25, D. C.

Products: Properties, Utilization and Analysis

Petroleum Solvents. W. T. HARVEY AND I. W. MILLS, *Anal. Chem.* **20** (1948) pp. 207-9.

The kauri butanol solvency test is rather tedious to perform and requires precise laboratory technique. Correlation is desirable to predict the kauri-butanol solvency values of petroleum spirits from other easily determined, standardized physical tests. Such a correlation was developed that relates the A.P.I. gravity, 50 percent boiling point, and aniline point with kauri butanol solvency values. This relation is expressed mathematically by two equations, one applying to solvents below 50 kauri, and the other applying to higher solvency materials. Detailed comparisons of determined and calculated values are given in four tables and a chart is presented giving a correlation of gravity, aniline point, and kauributanol solvency for petroleum solvents of 330 to 350° F. mid-boiling point. A bibliography of six references is included.

Suitability of Gasolines as Fuel. ROBERT R. JAMES AND ROSS E. MORRIS, *Ind. Eng. Chem.* **40** (1948) pp. 405-11.

A test procedure is described that will enable determination of the gum-forming tendencies of contaminates of gasoline. Gasoline was brought into contact with hose, gaskets, tanks, and other vessels that are lined or constructed with nitrile rubber vulcanizates. These plasticizers are extractable by gasoline and the suitability of gasoline as fuel can be affected. Extractable plasticizers can contaminate gasoline sufficiently to cause gum deposits in an internal combustion engine. Also the contamination of leaded gasoline by phosphate-bearing plasticizers will cause serious loss in octane rating. Forty-six plasticizers were studied and their effects on gumming and on octane rating are given. A bibliography of seven references is included.

Correlation of Predicted and Observed Storage Stability of Cracked Gasoline. E. L. WALTERS, D. L. YABROFF AND H. B. MINOR, *Ind, Eng. Chem.* **40** (1948) pp. 423-8.

Existing gasoline stability tests such as the induction period and copper dish gum are empirical and can lead to erroneous conclusions regarding stability, especially when widely varying types of gasolines are subjected to test. In storage stability the pertinent factor is the rate at which gum forms during storage, or, in other words, the length of time before gasoline forms objectionable quantities of gum and related deterioration products. Thus it appears that the rate of gum formation forms the logical basis of a stability best.

A test of this nature has been developed over a period of several years. The rate of gum formation is measured at

THE ETHYL CORPORATION SERVES THE PROGRESSIVE PETROLEUM INDUSTRY *Through Research*

ROAD PERFORMANCE...*the final proof of antiknock quality*

DETERMINATION of customer acceptance of fuels is complicated by continuous progress in the development of automotive engines and of fuel refining processes. Each advance in engine design is likely to result in some reversals of fuel preferences. Each new refining process usually yields a product which exhibits some unfamiliar type of antiknock performance.

To determine the performance of gasolines in cars driven by the general public today and to predict their performance in cars produced in the future, road tests are necessary. Conventional laboratory knock tests alone are not completely dependable indicators of the performance of fuels in service. Accurate road knock ratings are essential, not only on current commercial products, but also on future fuels which refiners may produce through variations in the operation of existing processes or by the installation of new equipment.

In the appraisal of fuel antiknock quality under actual service conditions, the Ethyl Research Laboratories cooperate closely with the engineering departments of motor vehicle manufacturers. As a result, Ethyl's engineers are able to choose a limited number of vehicles in which fuel knocking is suitably representative of the range of current engines, and to use some vehicles having engines which are modified to permit the rating of fuels likely to be required two or three years hence.

Accuracy Vital in Knock Rating

When only a few vehicles are employed for the knock rating of a given fuel, the accuracy of each observation must be of the highest order. Accordingly, the Ethyl Laboratories have installed in the test cars the finest instruments which they have been able to develop or procure for the indication of engine operating conditions during the conduct of knock tests. Special equipment permits frequent and convenient calibration of the installed instruments.

Road performance tests of experimental fuels are constantly being made in cooperation with oil companies.

Accuracy of electronic measuring instruments used in test cars is assured by frequent checking on this calibration machine.

A portion of the fleet of research ve in the garage, at the Ethyl Researc oratories in Detroit.

Ethyl's Detroit Laboratories are designed for research on problems related to fuel-engine-lubricant interrelationships.

Ethyl technical employees who plan and carry out cooperative knock rating studies with refiners have the benefit of extensive experience and a broad background relating to engines and fuels. As a consequence, they are able to plan such programs for economy of effort, execute them with a high degree of accuracy, and interpret the results in terms of their broad significance.

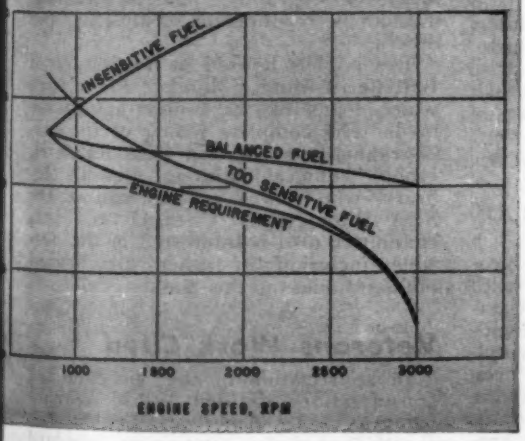
Cooperation with oil companies in knock rating studies on the road is just one of Ethyl's services to refiners in the evaluation of fuels, lubricants and engines. Ethyl's research and service program is designed to contribute substantially to the programs of oil companies which have as their objective the development of satisfactory and economical fuels and lubricants for today's and tomorrow's engines.

* * *

This is the second in a series of Ethyl Corporation advertisements concerning problems facing the petroleum refining industry, and outlining the services Ethyl provides to oil companies in evaluating and improving the performance of fuels.

ANTIKNOCK-SPEED RELATIONSHIP OF THREE DIFFERENT TYPE FUELS COMPARED WITH ENGINE ANTIKNOCK REQUIREMENT THROUGHOUT THE SPEED RANGE

	TEL	OCTANE NUMBERS	
FUEL	CC/GAL	MOTOR (F-2)	RESEARCH (F-1)
INSENSITIVE	3.0	98	94
TOO SENSITIVE	3.0	85	100
BALANCED	1.3	88	98



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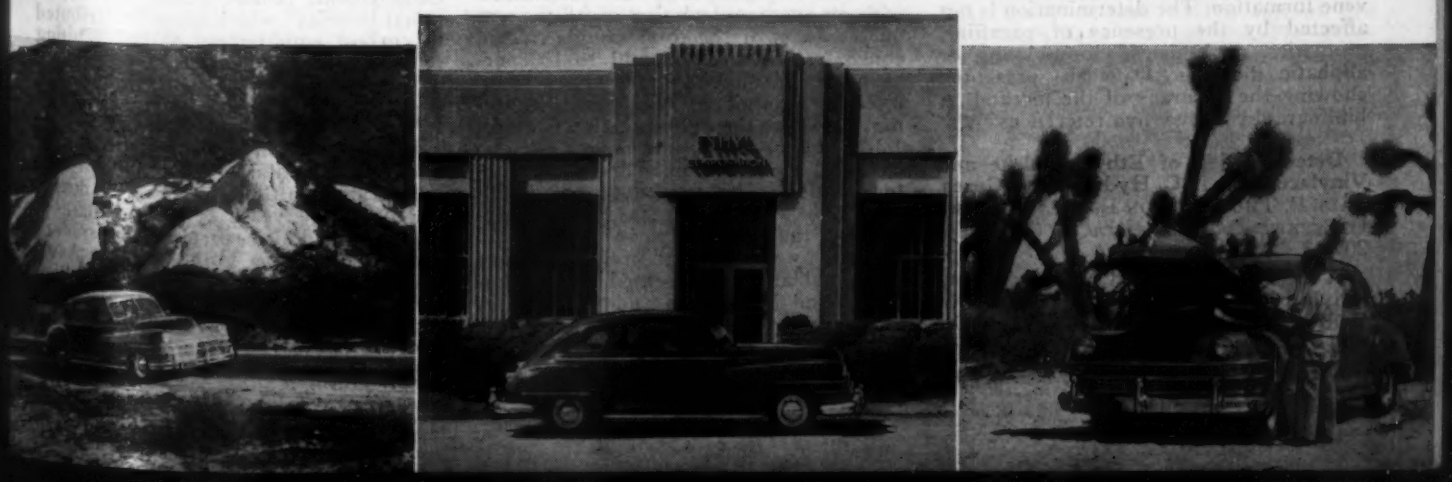

several accelerated conditions. The results are then extrapolated to give conditions of storage to furnish predictions of actual storage life. This paper shows the application of the extrapolated gum time method for predicting storage stability and its correlation with actual storage. Predicted storage stability lives were determined for a number of cracked gasolines by the extrapolated gum time method. In general, it was found the extrapolations correlate with actual storage within the precision of measurement. Gasolines tested represented all types of thermally cracked products in various states of refinement. The data are presented in considerable detail in tabular and graphical form and a bibliography of 11 references is included.

Permeability of Protective Glove Materials to Tetraethyllead and Ethylene Bromide. GEORGE CALINGAERT AND HYMIN SHAPIRO, *Ind. Eng. Chem.*, **40** (1948) pp. 332-5.

A large number of plastics and elastomers were tested for permeability to tetraethyllead and ethylene bromide, with the object of permitting manufacture of better protective work gloves. The main test employed was a gravimetric disk diffusion test. Several materials were shown to be from 10 to over 1000 times as impermeable to these liquids as neoprene. Most of the impermeable materials were unsuited for glove-making, but the nylons seemed promising and were investigated extensively. Gloves were fabricated of nylon alone and also of nylon compounded with neoprene, and the nylon-neoprene gloves are now in commercial production. A gravimetric method of testing the permeability of whole gloves is given. A bibliography of 12 references is included.

Determination of Cyclopentadiene and Methylcyclopentadiene in Admixtures with Other Hydrocarbons. J. S. POWELL, K. E. EDSON AND E. L. FISHER, *Analytical Chem.* **20** (1948) pp. 213-15.

The authors describe a method for quantitatively depolymerizing the dimers of cyclopentadiene and methylcyclopentadiene and determining individually the concentrations of the monomers in the resulting mixture. The method is based on the rate of condensation of cyclopentadiene and of methylcyclopentadiene with acetone in an alkaline solution to form the dimethyl fulvenes; and with benzaldehyde in an alkine solution to form the phenyl fulvenes. After neutralization with acetic acid, the intensity of the color produced is measured by means of a spectrophotometer. Concentrations of cyclopentadiene and methylcyclopentadiene are calculated from the extinction coefficients, which differ under the conditions of fulvene formation. The determination is not affected by the presence of paraffins, aromatics, naphthenes, mono-olefins, or aliphatic diolefins. Data are presented showing the accuracy of the method. A bibliography shows five references.

Determination of Ethylacetylene and Vinylacetylene in C_4 Hydrocarbon Gases. PAUL R. THOMAS, LEON DONN AND HARRY C. BECKER, *Analytical Chem.* **20** (1948) pp. 209-13.

A method is described for determining ethylacetylene and vinylacetylene in a C_4 hydrocarbon fraction. Total acetylenes were determined from the acidity produced upon treatment of a sample with 2.5 percent silver nitrate solution. Catalytic hydrogenation was used to distinguish between ethylacetylene and vinylacetylene after corrections had been made for the hydrogen consumed by the olefins and 1,3-butadiene. Olefins plus 1,3-butadiene were determined by bromine absorption and 1,3-butadiene by the use of maleic anhydride. Ethylacetylene and vinylacetylene were determined with an average deviation of 0.8 percent on the basis of the total sample over a concentration range from 1 to 100 percent. Methylamine and methylmercaptan interfere and, if present, must be removed before the determination is made. 1,2-Butadiene also interferes, but no chemical method is available for its determination. The percentage of vinylacetylene will be increased and consequently the ethylacetylene will be decreased by the amount of 1,2-butadiene present. Data are presented in considerable detail in 8 tables and 4 figures. A bibliography of 14 references is included.

BOOK REVIEW

In **"Synthetic Petroleum from the Synthine Process,"** the authors B. H. Weil and J. C. Lane have logically treated the subject matter under the following headings: production and purification of the synthesis gas; catalytic synthesis reactions; products, by-products and derivatives; basic economics and current developments. Of great importance for further study are the three appendices which comprise a classified list of over 2000 patents; an alphabetical, indexed list of government reports; and a supplemental bibliography.

Much attention is given to the theoretical and engineering phases of the process, with unusual emphasis on the nature and yield of products and by-products. Chemical derivatives will also be obtained in large quantities from the Synthine process, and these materials are given close attention.

The authors' efforts have been concentrated upon making this book up to the minute in a fast-moving field. Advances in German technology, revealed by American investigators, have been carefully scanned and discussed. American research and development has been covered in detail.

The book is published by Remsen Press Division, Chemical Publishing Company, Brooklyn. $6.75.

The Ninth Edition of **Standard Methods for Testing Petroleum and Its Products,** published by the Institute of Petroleum, 26 Portland Place, London, W. 1, England, may be obtained from the publishers at a price of 31 shillings, post free. Copies also are available from The American Society for Testing Materials, 1916 Race St., Philadelphia, at $6.75 a copy.

Numerous revisions have been made in this edition and several new test methods have been added. The arrangement of indexes and incidental text has been carefully reconsidered, the results being reflected in the greater convenience of the book to its users.

High Speed Photography Described in Two Reports

High speed photography methods used in the study of fuel injection and the observation of flame travel are described in two reports offered by the Office of Technical Services, Department of Commerce. Both of the methods were developed in Germany and employed intermittent spark illumination.

The first report contains information on a method of studying fuel injection photographically developed by Bosch research laboratory engineers. The problem was to obtain moving pictures of an injection spray which lasted .003 to .005 of a second. The interval between pictures was to be .001 to .002 of a second, and the exposure time, one-millionth of a second.

The report includes a photograph taken with the apparatus and a diagrammatic arrangement of the camera and electrical equipment.

The second report, prepared by G. B. R. Feilden of the British Intelligence Objectives Subcommittee, describes a high speed Schlieren camera for the observation of flame travel developed at Luftfahrforschungsanstalt, at Volkenrode, Germany. The camera operated at speeds up to 25,000 pictures per second, the duration of each exposure being about one microsecond.

Technical Bibliographies Are Available for Loan

Numerous rare and unpublished bibliographies on scientific and technical subjects are now available to industry as the result of the formation of a pool of unpublished bibliographies by the Special Libraries Association. Represented by the bibliographies are organic chemistry, agricultural chemistry, metallurgy, photography, physics, welding, mechanics, combustion technology, and others.

The pool is housed in the library of Battelle Institute, Columbus, Ohio, from which loans of the bibliographies are made. The complete listing of the bibliographies may be had from Ralph H. Hopp, technical librarian, Battelle Library, who serves as chairman of the SLA Bibliography Committee. This committee also is interested in the possible inclusion of other unpublished bibliographies in the pool.

Veterans Work Cited

In appreciation of the "benefits and considerations granted World War II veterans" the American Legion last month awarded a citation to Standard Oil Company (Indiana). Cited were the company's pioneering "in policies of reemployment, rehabilitation, and educational benefits" which have "contributed to current employment at the Whiting refinery of approximately 4000 veterans."

Diesel Locomotive Gain

Fifteen million horsepower will be added to the total of diesel locomotives in operation in the United States during the next five years is the estimate of Harvey T. Hill, executive director of the Diesel Engine Manufacturers Association. At present there are 7.1 million horsepower in all types of diesel locomotives in the nation.

DIGEST of Recent United States PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

AND COVERING PATENTS PUBLISHED IN THE OFFICIAL GAZETTE DATED FEBRUARY 10, 17, 24 AND MARCH 2

REFINING

U.S.P. 2,435,621. Method of Purifying a Hydrocarbon Material Containing Organic Halogen Compounds As Impurities. J. W. Brooks and J. B. Kirkpatrick to Socony-Vacuum Oil Company, Inc.

Hydrocarbon material which is contaminated by organic halogen compounds, such as material obtained by the alkylation of isoparaffins with olefins in the presence of halogen-containing catalysts and promoters, is contacted with anhydrous NH_3 or an aqueous solution thereof at a temperature of 400-800° F. and at a pressure greater than the vapor pressure of water at the treating temperature. The ammonia reacts with the halogen of the contaminating halides with formation of ammonium halides. The lead susceptibility of the hydrocarbon material is essentially improved by this treatment.

U.S.P. 2,435,792. Chemical Process. E. H. McArdle and D. M. Mason to Standard Oil Development Company.

A mixture of p-xylene and m-xylene as obtained for example as a by-product from the coking of coal and from certain petroleum conversion and separation processes after removal of admixed oxylene by fractionation, is dissolved in a diluent which has a freezing point lower than that of the eutectic of the two xylene isomers. The resulting solution which contains a higher proportion of p-xylene than is present in said eutectic is cooled to a temperature substantially below the eutectic point of the xylenes alone, i.e. below —58° C. Pure p-xylene crystals thereby precipitated from the solution are removed. The diluent is then evaporated from the remaining solution. The liquid left contains a higher proportion of m-xylene than is present in the eutectic. On cooling this liquid to a temperature at which the m-xylene crystallizes but above the eutectic temperature, m-xylene crystals can be obtained in a pure state. Ethane, ethylene, and isopentane are examples of the useful diluents.

U.S.P. 2,436,471. Vapor Phase Extraction. W. B. Franklin to Standard Oil Development Company.

A mixture of gaseous hydrocarbons, e.g. such which contains butadiene, is scrubbed with an aqueous metallic salt solution capable of selectively taking up at least one of the hydrocarbon constituents, such as an ammoniacal solution of couprous acetate. An amount of a hydrocarbon carrier liquid not substantially in excess of 0.1 percent by volume of the scrubbing solution which is immiscible therewith is added. The carrier liquid shall be chemically inert to the scrubbing solution and to the gaseous constituents to be treated and shall have strong solvent power for the latter. Naptha is an example of such carrier liquid. The efficiency of the scrubbing operation is greatly increased by this addition.

U.S.P. 2,436,149. Extraction of a Diolefin. N. Menshih to Standard Oil Development Company.

A mixture of hydrocarbons containing a diolefin, e.g. isoprene, is contacted with an excess of SO_2, e.g. 3.5 mols for each mol of the diolefin. The resulting mixture containing SO_2 hydrocarbons, and sulfone formed is heated to drive off the excess SO_2. The residual mixture is allowed to settle at a lower temperature, two liquid layers being formed. The separated lower layer is heated to decomposition temperature (e.g. 248-275° F.) whereupon the re-formed diolefin is separated.

U.S.P. 2,436,472. Vapor Phase Solvent Extraction Process. E. F. Wadley to Standard Oil Development Company.

The process of this patent is similar to that of U.S. patent 2,436,471. In the present case at least 3 percent by volume and preferably 5-20 percent of the hydrocarbon carrier are added to the scrubbing liquid. After treatment, the scrubbing liquid containing absorbed gaseous constituents of the mixture treated is separated from the carrier liquid containing dissolved constituents. The absorbed and the dissolved hydrocarbon constituents are separately recovered from said liquid.

U.S.P. 2,436,502. Furfural Recovery. C. K. Buell and C. F. Weinaug to Phillips Petroleum Company.

Furfural, as used in the extraction of hydrocarbon products, is recovered from admixture with foam producing oils which cannot be readily removed by distillation. For this purpose the furfural-oil mixture is extracted with water at a temperature of 90-150° F. The quantity of water used is controlled so that the resulting aqueous phase is from 50 to 25 percent saturated with furfural. This aqueous phase is fractionally distilled, an overhead fraction of furfural and water in azeotropic proportions being obtained which is condensed. The condensate is caused to separate into a water phase and a furfural phase essentially free of oils. The water phase is used as a reflux in the fractionating column.

U.S.P. 2,436,838. Stabilization of Tetraalkyl Lead and Compositions Containing the Same. H. Von Bramer and A. C. Ruggles to Eastman Kodak Company.

The patent relates to a hydrocarbon motor fuel which contains a tetraalkyl lead compound, a halogenated hydrocarbon lead scavenger and a small amount of a derivative of a p-phenylenediamine in which one H atom of each amino group is replaced by a secondary or tertiary alkyl group. This motor fuel is stable and does not tend to form appreciable gum upon storage. Formation of haze during storage is retarded by the addition of the p-phenylendiamine.

U.S.P. 2,437,041. Hydrocarbon Fuel Oil. W. A. Proell to Standard Oil Company (Indiana).

The liquid hydrocarbon oil according to this patent contains a filtered technical grade phosphatide free of liquid hydrocarbon precipitable constituents, e.g. lecithin. The additive is obtained by dissolving the phosphatide in a hydrocarbon solvent and filtering the mixture. The amounts of this additive shall be small but sufficient to inhibit the formation of non-casual sediment in the oil and the clogging tendency of the fuel oil at small apertures.

U.S.P. 2,437,045. Determination of Hydrocarbon Concentration in Soil Samples. E. E. Roper to Stanolind Oil and Gas Company.

To determine an index of the concentration of hydrocarbons sorbed on a soil sample, de-aerated, similar portions of the sample are separately subjected to an artificial atmosphere. Each of these atmospheres initially contains a different known concentration of hydrocarbons. When substantial equilibrium between the partial pressures of the hydrocarbons sorbed on the soil is established, the concentration of hydrocarbons in each of these atmospheres is determined, whereby the desired index can be obtained.

U.S.P. 2,437,230. Recovery of Olefinic Hydrocarbons. R. C. Morris and T. W. Evans to Shell Development Company.

A diolefin, such as butadiene or isoprene, is separated from a gaseous hydrocarbon mixture which also contains a more saturated hydrocarbon with the same number of C atoms as the olefin by contacting this mixture with a liquid solvent which consists of water and acetonitrile, propionitrile, or lactonitrile. The water content of the solvent can vary from 10-68 mol. percent. The diolefin is selectively dissolved and separated from the residual gas.

U.S.P. 2,436,698. Process for Separating Olefins from Hydrocarbon Mixtures. A. G. Oblad to Socony-Vacuum Oil Company, Inc.

Olefins with 3-5 C atoms are separated from close-boiling paraffins by admixing a molar excess of benzene on the basis of the olefins in the charge mixture. The resulting mixture is pre-alkylated in the presence of an alumina-

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silica type catalyst at a temperature above 300° C. and a pressure of 700-1500 psi. The gaseous effluent of the reaction is cooled to below 300° C. and subjected to final alkylation at a temperature of 175-300° C. and a pressure below 300 psi. in the presence of the same kind of catalyst. From the effluent of this second alkylation step a paraffin stream, unreacted benezene and alkyl benzene are obtained by fractionation. The alkyl benzene is dealkylated and the resulting effluent is further treated in a manner described in detail to recover the olefins.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,435,710. Method for Producing Sulfur Dioxide from Waste Sulfuric Acid-Hydrocarbon Containing Material. R. T. Collier, and J. G. Carriere to Union Oil Company of California.

SO_2 is produced from waste H_2SO_4 as obtained in the treatment of hydrocarbons (e.g. inalkylation processes) by heating the waste acid with a heating gas above the decomposition point of the acid but below the cracking temperature of the hydrocarbons contained in this acid and below the vaporization point of a substantial portion of these hydrocarbons. Details of this process are claimed.

U.S.P. 2,436,041. Catalytic Conversion of Hydrocarbons. C. G. Gerhold and J. E. Burgess to Universal Oil Products Company.

The patent relates to a process for the removal of combustible contaminants from a bed of non-combustible subdivided solids susceptible to damage at excessively high temperature. The bed is maintained in a relatively dense fluid-like state and oxidizing gas is passed upwardly into this bed at a velocity regulated to partially counteract the force of gravity on the solid particles. The temperature of combustion of the contaminants and the rate of supply of free oxygen in the oxidizing gas are controlled. The resulting combustion products are discharged through a region within a confined zone of the bed of solids where the concentration of these solids is materially reduced.

U.S.P. 2,436,125. Silica-Zirconia Catalysts and Method of Preparation. L. U. Spence, D. J. Butterbaugh, and D. G. Kundiger to Rohm & Haas Company.

The catalyst according to this patent is suitable for converting ethanol to butadiene. It consists of a mixture of 20-90 percent silica and 80-10 percent of thorium or zirconium oxide. The mixture is first heated at a temperature of at least 50° C. in an aqueous solution of a quaternary ammonium base or the hydroxide or silicate of an alkali metal for digestion, then freed from water-soluble materials, brought to a pH of 8-9, and dried.

U.S.P. 2,436,225. Apparatus for Contacting Solids with Gaseous Fluids. H. J. Ogorzaly and W. P. Lakin to Standard Oil Development Company.

The apparatus according to this patent is used in stripping or purging fluidized

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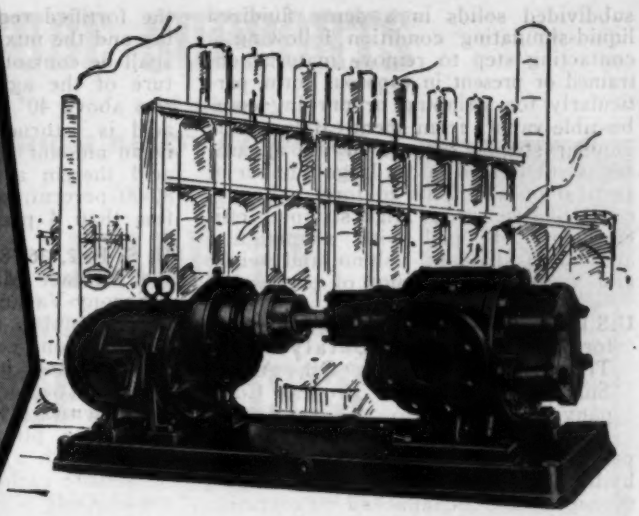

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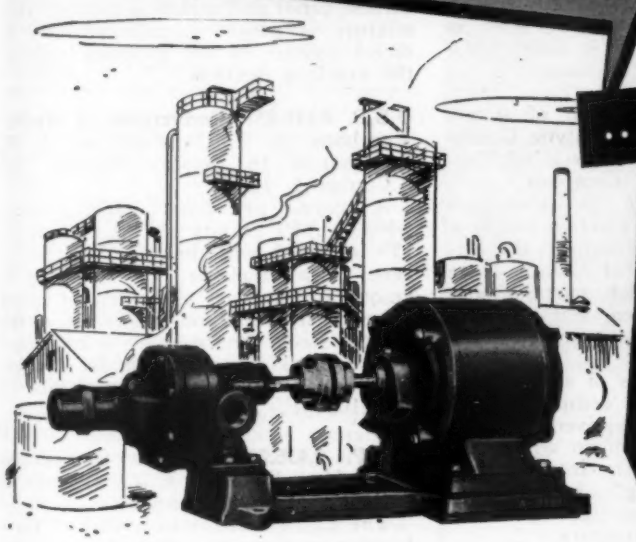

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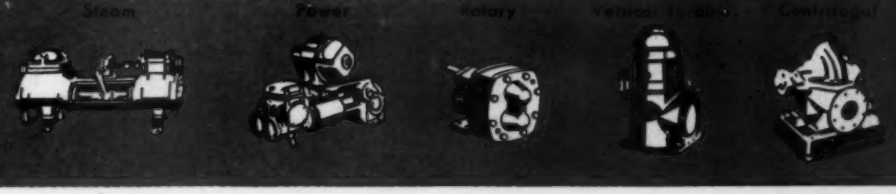

subdivided solids in a dense fluidized liquid-simulating condition following a contacting step to remove material entrained or present in vaporous form, particularly for stripping or purging combustible vapors from spent catalyst. The annular stripping space of the apparatus is subdivided into a large number of vertical parallel cells to form a honeycomb-like structure. High stripping efficiency is obtained with a minimum amount of stripping volume and height and a minimum amount of purge gas.

U.S.P. 2,436,495. Process and Apparatus for Adsorptively and Catalytically Treating Hydrocarbon Oil. A. D. Smith to Adsorptive Process Company.

For regenerating dispersed catalyst particles spent in the conversion of fluid hydrocarbons, these particles are flown through a multi-channelled regeneration zone in the absence of free oxygen countercurrently to steam, superheated to such degree that metathesis occurs between the carbon adsorbed on the catalyst and the steam. The catalyst is regenerated and a composite gas comprising CO, CO_2, and H_2 is produced. Combustion of this composite gas is effected and a portion of the heat thereby generated is employed to externally heat the regeneration zone and another portion to superheat the steam.

U.S.P. 2,436,496. Process for the Catalytic Treatment of Hydrocarbon Oil. A. D. Smith to Adsorptive Process Company.

This patent makes use of the catalyst regeneration process of U.S. patent 2,436,495 in a process for the catalytic conversion of fluid hydrocarbons, and the details of this process are described and claimed in combination with said regeneration process.

U.S.P. 2,436,558. Process of Producing Catalysts Containing Barium Peroxide. K. C. Edson and F. E. Fisher to Skelly Oil Company.

A catalyst carrier is impregnated with an aqueous solution of a water-soluble compound of Cr, Mo, or V. The resulting mixture is dried and heated to a temperature sufficient to produce an oxide of the element in question. The resulting product is impregnated with an aqueous solution of barium nitrite and heated under oxidizing conditions to a temperature sufficient to decompose the nitrite and to oxidize the BaO thus formed to BaO_2. The catalyst obtained is particularly useful in aromatization reactions.

U.S.P. 2,437,091. Sulfuric Acid Fortification in Isoparaffin Alkylation. A. R. Goldsby and C. W. Watson to The Texas Company.

In the continuous alkylation of an isoparaffin with an alkylation agent in the presence of conc. H_2SO_4 with recycling of a substantial proportion of the catalyst separated from the alkylation effluent and discharging of the remaining proportion of this catalyst, the recycle acid stream is chilled to 20-30° F. A stream of fuming sulfuric acid is then added to this stream with agitation. The strength and amount of fuming acid added is controlled in accordance with the water content of the recycle acid to reduce the water content of the latter to less than 1 percent by weight while avoiding any free SO_3 in the fortified recycle stream. The chilling and the mixing of both acid streams shall be controlled so that the temperature of the agitated mixture does not rise above 40° F. The fortified recycle acid is returned to the reaction zone in an amount sufficient to maintain the acid therein at a titratable acidity of 80-90 percent, with a water content of less than 4 percent by weight.

U. S. P. 2,436,780. Method for Handling a Contact Mass. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

A granular form solid used as a hydrocarbon conversion catalyst and contaminated by a carbonaceous deposit is passed as a compact mass of downwardly gravitating granules through a plurality of burning zones and through a heat exchange zone intermediate each two successive burning zones. Only a controlled amount of an oxygen containing preheated gas is passed in direct contact with the solid in each burning zone. The resulting regeneration gases are discharged from each burning zone and not allowed to enter a successive zone. The solid is cooled after regeneration in each of the zones by indirect heat exchange.

U.S.P. 2,426,927. Prevention of Afterburning in Fluidized Catalytic Cracking Processes. L. S. Kassel to Universal Oil Products Company.

In the regeneration of subdivided silica-alumina catalyst wherein the flow of the regenerating gas through the catalyst is regulated to form a lower dense phase of relatively high particle concentration and an upper light phase of reduced particle concentration and the contaminant is burned in the dense phase, discrete particles of a supported CO oxidizing catalyst comprising Cr, Cu, Mn, Co, or Ni are mixed with the silica-alumina catalyst in an amount of 0.0005-0.01 percent of the total catalyst mixture. "Afterburning" of the regenerated catalyst in the light phase is prevented by this admixture.

CRACKING AND REFORMING

U.S.P. 2,435,760. Thermal Conversion of Hydrocarbons Promoted by Explosive Organic Nitrogen Compounds. C. M. Thacker and H. O. Folkins to The Pure Oil Company.

Hydrocarbons, particularly such with 3 or more C atoms are subjected to cracking temperature in the presence of a small amount of nitroglycerin, trinitrotoluene, trinitroxylene, tetryl, picric acid, cellulose hexanitrate, or nitromannite. The explosive can be added in an amount of 0.25-3 mole percent based on the hydrocarbon. It works as a promoter to achieve the thermal conversion of the hydrocarbons under milder conditions or to obtain higher yields.

U.S.P. 2,436,160. Cracking of Hydrocarbon Oils with Finely Divided Heat Resistant Non-Catalytic Material. F. H. Blanding to Standard Oil Development Company.

Hydrocarbon oil to be cracked in a continuous process is directly injected into a fluidized mass of finely divided, non-catalytic, heat resistant material in a reaction zone maintained at a temperature of 1200-2200° F., to cause cracking of the oil. The products leaving the fluidized mass are quenched immediately above the fluidized mass to reduce their temperature. Contaminated finely divided material is continuously withdrawn, regenerated by combustion of the contaminants, and returned to the reaction zone without cooling.

U.S.P. 2,436,254. Process and Apparatus for the Thermal Cracking of Hydrocarbons. S. C. Eastwood and R. D. Drew to Socony-Vacuum Oil Co., Inc.

In the thermal cracking of hydrocarbons a hot granular solid is passed downwardly through a contacting zone which includes a charge preparation section superposed by a high temperature cracking section. Liquid hydrocarbons are introduced to the upper part of the preparation section to be caporized and preheated by contact with hot solids from the cracking section. Liquid water is introduced to the lower part of the preparation section to be vaporized and preheated. Vapors from both these parts are flown to an intermediate part of this section where a mixture of hydrocarbon vapor and steam is formed. This mixture is passed countercurrently in direct contact to the granular solid in the cracking section.

U.S.P. 2,436,257. Conversion of Hydrocarbons. R. C. Hansford and A. N. Sachanen to Socony-Vacuum Oil Company, Inc.

A recycle petroleum cracking stock with an API gravity of less than about 15° is mixed with benzene, alkyl benzene, naphthalene, or diphenyl in amounts of at least ½ volume of added aromatic hydrocarbon to one vol. of the recycle stock. The mixture is contacted with a cracking catalyst under suitable conditions including a temperature of 800-1100° F.

U.S.P. 2,436,282. Surface Combustion Cracking Furnace. E. O. Bennett to Continental Oil Company.

The patent relates to a surface combustion cracking furnace to be used particularly in the cracking of hydrocarbon fluids into C and H_2 for the production of superior grade carbon black. Details of the apparatus are described and claimed.

U.S.P. 2,436,464. Fluid Catalytic Cracking. E. M. van Dornick.

The patent describes and claims the details of a process of catalytically cracking an oil feed stock flashed in contact with finely divided hot catalyst. The effluent vapors of the conversion operation are separated from the catalyst, the latter is regenerated and forced under pressure into the feed stock to be treated.

U.S.P. 2,436,486. Multistage Hydrocarbon Cracking Process. F. W. Scheineman to Standard Oil Company (Indiana).

In a process of catalytically cracking hydrocarbons in two conversion zones by means of finely divided catalyst particles which are regenerated, a dense turbulent catalyst phase is maintained in the regeneration zone (which is superimposed by a dilute catalyst phase) by passing regeneration gases upwardly through this zone at low velocity. Hot catalyst from the dense phase is directly withdrawn to the first conversion zone to which high boiling hydrocarbon

charging stock is introduced at a low point and at such a rate as to maintain a dense turbulent catalyst phase therein. Only partial cracking is effected in this zone. After short residence catalyst is directly returned from this zone to the regeneration zone. Cooled catalyst from the dense phase of the regeneration zone is introduced into the second conversion zone where all products obtained in the first conversion zone are introduced at a low point under similar conditions as at the first zone. Further cracking with use of longer catalyst residence time is effected in the second zone. The cracking products removed from this zone are fractionated.

U.S.P. 2,436,618. Conversion of Hydrocarbon Oils. W. J. Sweeney to Standard Oil Development Company.

A stream of higher boiling hydrocarbons is passed in a cracking zone maintained at a temperature of 850-1000° F. over a cracking catalyst. Details of the cracking operations and of the fractionation of the cracking effluent are given. A heavy naphtha fraction obtained, which contains a major portion of aromatic constituents, is hydrogenated under nondestructive conditions. The hydrogenated heavy naphtha formed, which contains naphthenes, is combined with a light naphtha fraction from the cracking effluent and then further cracked at a temperature of 500-850° F. to reduce the olefin content. A motor fuel is obtained from this cracking effluent by fractionation.

U.S.P. 2,436,622. Catalytic Cracking and Refining of Hydrocarbon Oils. C. W. Tyson to Standard Oil Development Company.

A heavy hydrocarbon oil boiling above the end point of naphtha is contacted at a temperature above 700° F. with a finely divided catalyst. The cracking effluent is fractionated. A segregated naphtha fraction obtained is contacted in vapor form with a refining catalyst at a temperature above 500° F. The refined vapors separated from the bulk of the finely divided refining catalyst but containing entrained refining catalyst are contacted while at the refining temperature with fresh oil which is subjected to the first-named cracking treatment. The same type of catalyst can be used in both treatments.

ISOMERIZATION

U.S.P. 2,436,944. Isomerization of Saturated Hydrocarbons. R. E. Sutherland to Universal Oil Products Company.

The reaction products from the isomerization of saturated hydrocarbons in the presence of a metal halide catalyst and a hydrogen halide, after removal of the sludge formed, are fractionally distilled to separate isomerized hydrocarbons and the hydrogen halide as overhead from a liquid bottoms containing dissolved metal halide. At least a portion of the bottoms is returned to the isomerization step. A vapor stream of hydrocarbons lower in metal halide concentration than the liquid in equilibrium therewith is withdrawn from the fractionating zone at a point below that of the introduction of the isomerization reaction products. This stream which comprises

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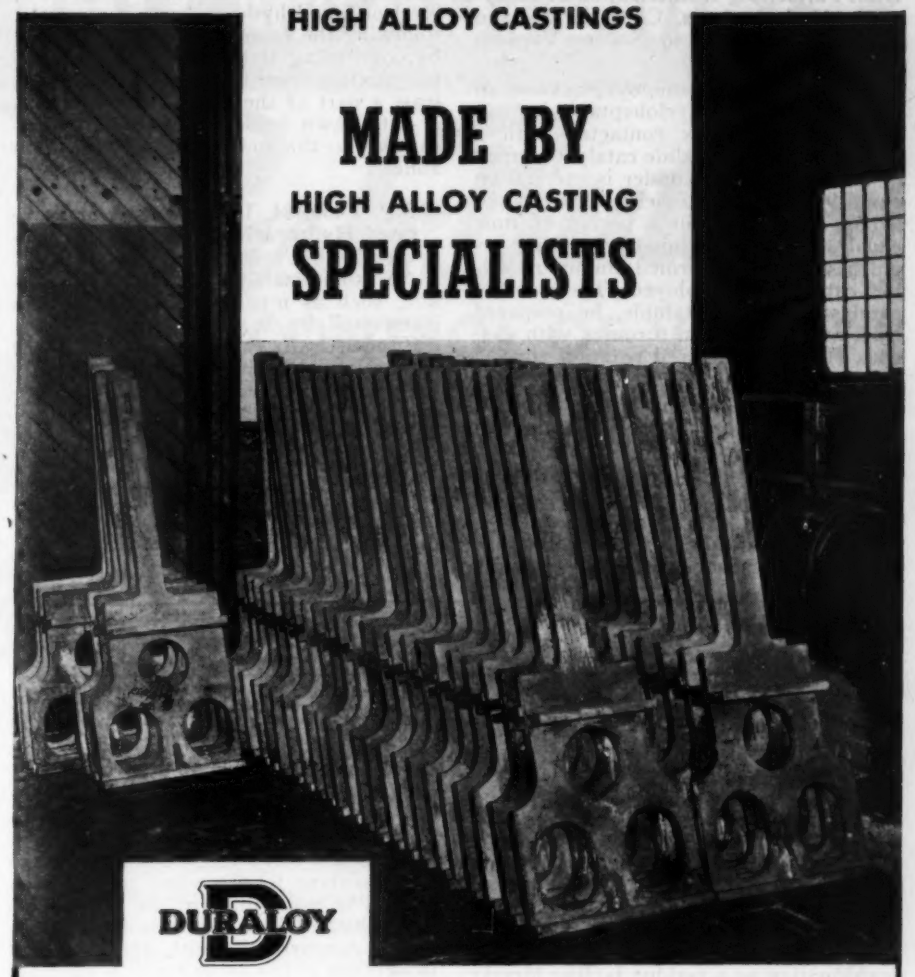

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hydrocarbons boiling higher than the charged saturated hydrocarbons is removed.

U.S.P. 2,435,691. Isomerization of Alicyclic Hydrocarbons. C. G. Myers and A. N. Sachanen to Socony-Vacuum Oil Company, Inc.

An alkylcyclopentane, cyclohexane, an alkylcyclohexane, cycloheptane, or an alkylcycloheptane is contacted with a nascent aluminum halide catalyst formed in the reaction zone under isomerization conditions. Optimum yield of the desired isomer is reached in a period of time equal to about one quarter of that required when a preformed aluminum halide catalyst is employed. The nascent catalyst can, for example, be prepared by heating aluminum turnings with gaseous HCl in the closed reaction zone.

U.S.P. 2,436,367. Isomerization Process. W. Swerdloff to Socony-Vacuum Oil Company, Inc.

The patent relates to a continuous liquid phase stepwise process for isomerizing at least one normal paraffin hydrocarbon by means of a catalyst soluble in this hydrocarbon under isomerization conditions, e.g., $AlBr_3$. The reaction is carried out in at least two separate isomerization zones. The partially isomerized mixture of each zone is vaporized for transfer to the succeeding zone. The level of liquid hydrocarbons in any zone following the primary zone is controlled by condensing at least a part of the vapor mixture from the preceding zone. At least a part of the heat of condensation is withdrawn before passing the hydrocarbons to the succeeding isomerization zone.

U.S.P. 2,436,484. Isomerization of Saturated Hydrocarbons. H. Pines to Universal Oil Products Company.

An isomerizable saturated hydrocarbon, such as n-pentane or n-hexane, is isomerized by a suitable catalyst, e.g., a Friedel-Crafts catalyst, in the presence of a relatively minor amount of a partially hydrogenated polynuclear aromatic hydrocarbon, such as partially hydrogenated naphthalene or anthracene. The addition of such an aromatic hydrocarbon selectively suppresses decomposition reactions and permits the isomerization of the paraffins with a high degree of efficiency and low catalyst consumption.

ALKYLATION

U.S.P. 2,435,708. Process for the Production of Synthetic Isoparaffinic Oil. A. C. Byrns to Union Oil Company of California.

Normally gaseous olefins are reacted with an isoparaffinic feed stock containing isobutane in molal excess in the presence of an alkylation catalyst, such as conc. H_2SO_4. An isobutane fraction obtained from the reaction products is recycled. The desired heavy alkylate fraction formed is recovered during fractionation as a residue boiling largely between 400-800° F. An intermediate isoparaffinic fraction obtained and boiling between 300-400° F. is alkylated in a second stage to form an alkylation product of about the same boiling range as that obtained in the first stage.

U.S.P. 2,435,761. Alkylation of Hydrocarbons. C. M. Thacker to The Pure Oil Company.

Paraffin hydrocarbons, e.g., such with 4-7 C atoms, are contacted with olefins or alkyl chlorides under alkylating conditions in the presence of BF_3 and Cl_2 or Br_2 as a promoter. 0.25-10 percent by weight of the promoters calculated on the hydrocarbons employed can, for example, be added.

U.S.P. 2,436,151. Alkylation of Aromatic Hydrocarbons by Contact with Heat-Stable Metal Halide Catalysts. A. A. O'Kelly and R. H. Work to Socony-Vacuum Oil Company, Inc.

An aromatic hydrocarbon, such as benzene, is contacted with an olefin, such as ethylene, at a temperature not substantially below 550° F. in the presence of a metal halide catalyst stable at the reaction temperature and a halogenated hydrocarbon. $ZnCl_2$ or $FeCl_3$ and chlorinated petroleum naphtha can, for example, be employed as the catalyst. Monoalkyl and dialkyl aromatics are predominantly obtained in high yields.

U.S.P. 2,436,483. Alkylation of Isoparaffins. R. J. Newman to Universal Oil Products Company.

Isobutane is alkylated with an olefin, such as propylene and butylene, while isopentane is separately alkylated with propylene in the presence of HF at a temperature of 75-150° F. A molar ratio of isopentane to propylene of from 5:1 to 20:1 is maintained in the latter step. The substantial amount of isobutane produced concurrently with the alkylated isopentane in the second step is supplied to the first alkylating step.

U.S.P. 2,436,695. Alkylation Process. G. S. Kuhn, Jr., to Socony-Vacuum Oil Company, Inc.

An isoparaffin is alkylated with an olefin, in the presence of HF. The used catalyst containing disolved organic by-products formed is separated and divided into two portions. One of these portions is distilled to separate the HF as an overhead from said by-products and is returned together with the other portion of the used catalyst to the alkylation zone. The ratio of catalyst in the portion distilled to that in the portion returned without distillation is adjusted so as to maintain the concentration of organic impurities dissolved in the catalyst in the alkylation zone at 1-8 percent by weight.

U.S.P. 2,436,965. Alkylation of Hydrocarbons. K. Korpi and A. R. Goldsby to The Texas Company.

Isoparaffins are alkylated with olefins in the presence of H_2SO_4 of suitable concentration. A low concentration of alkyl ester initial reaction product corresponding to a gasoline or motor fuel product of unsaturation below about 2 percent is maintained. This can be effected by suitable control of the ratio of acid present to the hydrocarbons used. Motor fuel hydrocarbons in the gasoline boiling range having a high antiknock value are obtained.

POLYMERIZATION AND CONVERSION

U.S.P. 2,436,170. Finishing of Aviation Naphthas. B. N. Hill to Standard Oil Development Company.

The effluent from a hydrocarbon catalytic cracking operation is divided at least into two fractions, one of which comprises at least a major portion of constituents boiling between 110° and 210° F. to the exclusion of constituents boiling above 270° F., while another fraction comprises at least a major portion of constituents boiling between 270° and 330° F. to the exclusion of constituents boiling below 210° F. and comprising paraffins and aromatics. The first named fraction is catalytically hydrogenated, and the second named fraction is refined by thermal cracking to convert paraffins to olefins followed by treatment with conc. H_2SO_4 to remove the olefins without reducing the aromatic content of the fraction. Both fractions are then recombined. Maximum yield of high-grade aviation fuel is obtained by this process from the original cracking effluent.

U.S.P. 2,436,238. Interpolymerization of Olefins. E. F. Wadley and J. T. Horeczy to Standard Oil Development Company.

A mixture of olefins of different molecular weights is contacted with H_2SO_4 of 50-80 percent concentration containing 5-25 percent of BF_3 at a temperature of 125-300° F. for a period sufficient to effect interpolymerization of the olefins, e.g., for 15-90 minutes.

U.S.P. 2,436,256. Process for Polymerizing Ethylene. W. E. Hanford and P. L. Salzberg to E. I. du Pont de Nemours & Company.

Ethylene is contacted in the absence of oxygen at a temperature of 100-350° C. and a pressure of 200-3000 atm. with a catalyst comprising hypochlorites or substances which yield hypochlorites on hydrolysis with dilute alkali. Ethylene polymers are formed.

U.S.P. 2,436,571. Polymerization of Olefins. R. L. Heinrich to Standard Oil Development Company.

Propylene is contacted in admixture with a mono-olefin having a greater number of C atoms than propylene, e.g., 4 or 5, with H_2SO_4 of 60-85 percent concentration in the presence of isopropyl ether in an amount of 5-15 percent by volume. A hydrocarbon phase obtained is separated from the acid phase and fractionated into an ether fraction and a polymer fraction. The ether fraction is reused to maintain the amount of ether in the fraction zone within the indicated range. An undesired increase in the formation of isopropyl ether in the production of said polymers is suppressed by maintaining the ether concentration constant.

U.S.P. 2,436,332. Rubber Composition. P. E. Rollhaus to The United Gas Improvement Company.

The patent relates to a composition comprising a rubber-like butadiene-styrene, or the like, copolymer and a heat polymer of a residual tar separated from tar-water emulsion obtained in the pro-

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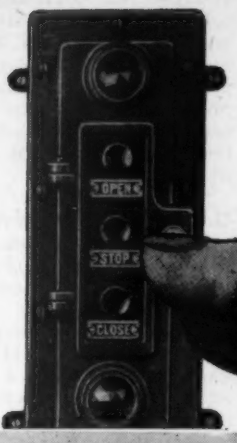

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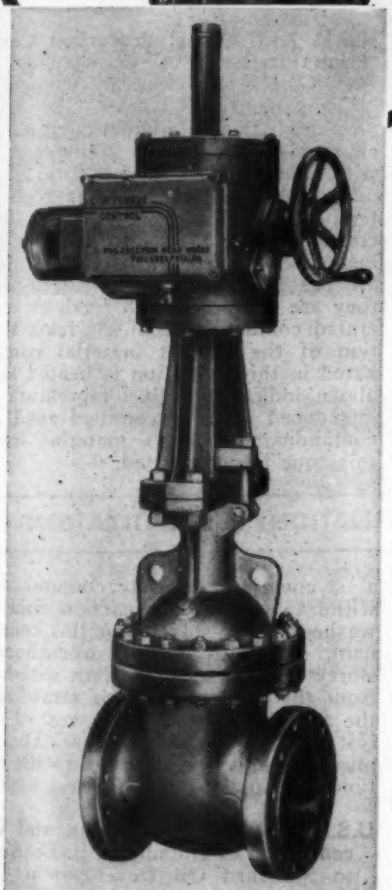

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U.S.P. 2,436,340. Conversion of Hydrocarbons Using Moving Catalysts. J. D. Upham and I. L. Wolk to Phillips Petroleum Company.

Catalytic hydrocarbon conversion is effected in at least two stages with the use of a moving bed of granular catalyst in at least one of these stages and a finely powdered catalyst of smaller particle size in another of these stages. The granular catalyst is regenerated in a moving bed in at least one regenerating stage and the powdered catalyst in another stage. Effluent regenerative gases containing powdered catalyst are passed to the first named regeneration stage to separate suspended powdered catalyst from the gases by incorporation in the bed of granular catalyst. Powder carried over from the powdered catalyst stage and powder formed by attrition of the granules of the other catalyst can be separated from the granular catalyst and passed to the powdered catalyst stage.

U.S.P. 2,436,564. Pretreatment of Reaction Zone Containing Iron Oxide. O. Gerbes to Standard Oil Development Company.

It has been discovered that reactions involving anhydrous admixtures of a hydrogen halide and hydrocarbons should be carried out in a reaction zone free from iron oxides. It is, therefore, the object of this patent to pretreat a reaction zone to be used in the catalytic conversion of hydrocarbons in the presence of anhydrous halogen halide and $AlCl_3$ supported upon a porous solid in such a manner that the iron oxide originally present in small amounts in the reaction zone which also contains the porous solid free of $AlCl_3$ is removed. For this purpose anhydrous hydrogen halide is introduced into the reaction zone prior to the $AlCl_3$ to transform the iron oxide into the halide and water. The water formed is then removed by a gas stream, whereupon $AlCl_3$ and hydrocarbon feed stock are introduced for the conversion of this stock.

U.S.P. 2,436,595. Conversion of Hydrocarbon Gases. E. W. S. Nicholson and A. K. Redcay to Standard Oil Development Company.

A hydrocarbon gas, such as methane, is converted into higher boiling hydrocarbons by passing the gas through a conversion zone containing a layer of finely divided catalyst while controlling the velocity of the gas to be converted and of the air to be used for regenerating the catalyst. Details of this process are described and claimed.

U.S.P. 2,436,614. Solid Styrene Polymer Formation at Low Temperatures. W. J. Sparck, H. B. Kellog, and D. C. Field to Standard Oil Development Company.

Vinyl aromatic hydrocarbons, such as styrene or methyl styrenes, are dissolved in an alkyl chloride with 1-2 C atoms. The solution is cooled to a temperature between —78° and —103° C. A Friedel-Crafts catalyst dissolved in the same kind of solvent is added to effect polymerization. Resinous polymers are obtained.

U.S.P. 2,436,767. Low-Temperature Polymer Production. R. A. Gerlicher to Jasco, Inc.

Liquefied isobutylene-containing material is cooled to a temperature between 0° and —110° C., stirred through a helical cardioid path and returned to the center of this path for recirculation. Volatilized gases from the stirred material are vented through a central path from the returned liquid, past a free-falling, non-splashing stream of the same material. A supply of Friedel-Crafts polymerizing catalyst in fluid form is fed to the circulating stream of material while traveling in the helical path. Solid polymer is obtained. Obstruction of the circulating path during the reaction is prevented by the free-falling character of the helical stream.

U.S.P. 2,436,900. Method for the Removal of Traces of Water from Mixtures of Hydrogen Chloride with Low-Boiling Hydrocarbons. P. L. Roberts to Phillips Petroleum Company.

Low-boiling paraffin hydrocarbons, such as n-butane, which are converted in the presence of a Friedel-Crafts metal halide catalyst activated with hydrogen halide are treated to remove small amounts of water contained in the system by concentrating the water in a hydrogen halide-rich stream which contains less than about 1 mol. percent water based on the hydrogen halide content. This stream is contacted with a liquid metal halide-hydrocarbon complex containing free metal halide at a temperature of 75-175° F., whereby the water is removed. The process is useful also for the drying of a hydrogen halide containing hydrocarbon material generally.

U.S.P. 2,436,922. Catalytic Conversion Process. H. W. Grote to Universal Oil Products Company.

A heavy hydrocarbon oil is subjected to indirect heat exchange with vaporization products, as mentioned below, and commingled with hot oxygen-free combustion gases from a catalyst regeneration step. The resulting mixture is flash vaporized to separate vaporization products comprising combustion gases and lower boiling hydrocarbons from a higher boiling hydrocarbon residue. The vaporization products are cooled by indirect heat exchange with the heavy hydrocarbon oil to condense the lower boiling hydrocarbons. The heat exchange and the hot combustion gases are the sole sources of heat supplied to the heavy hydrocarbons. The resultant lower boiling hydrocarbon condensate is supplied as charge to a catalytic conversion process. The regeneration of catalyst used by this process furnishes the combustion gases used in heating the heavy hydrocarbon oil.

U.S.P. 2,436,929. Polymerization of Olefinic Hydrocarbons. C. B. Linn to Universal Oil Products Company.

An olefinic hydrocarbon, such as propylene or butylene, is polymerized in the presence of a catalyst consisting essentially of liquid HF containing an alkali metal fluoride or sulfate. The ordinarily vigorous reaction of HF on the olefins is moderate by the salt additive.

U.S.P. 2,437,222. Hydrocarbon Conversion Process. J. A. Crowley, Jr., and O. G. Hayes to Socony-Vacuum Oil Company, Inc.

A high boiling liquid hydrocarbon charge is contacted in a confined zone with contaminated particle form contact material introduced into this zone at a temperature sufficiently high to effect conversion of the charge to lower boiling gaseous hydrocarbons. The latter are passed to a conversion zone where they are contacted with fresh or regenerated contact material. At least a portion of the contact material contaminated in this operation is heated to the above indicated high temperature and introduced into the confined zone. The contaminated contact material leaving this zone is regenerated.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,436,480. Production of Alkyl Aromatic Hydrocarbons. J. M. Mavity to Universal Oil Products Company.

A mixture of an alkylatable aromatic hydrocarbon and a dehydrogenable paraffin hydrocarbon is contacted with a dehydrogenation catalyst, such as an oxide of the elements of the left hand columns of groups IV, V, or VI of the periodic table, under dehydrogenating conditions to form an olefin hydrocarbon from the paraffin. At least a portion of the resultant mixture is contacted without further chemical treatment with an alkylation catalyst under conditions suitable to alkylate the aromatic hydrocarbon with the olefin. A recycle fraction comprising unconverted aromatic and paraffin hydrocarbons is separated from the resultant alkylation products and supplied to the dehydrogenation step. The aromatic shall be present in molecular excess over the paraffin in the feed mixture, e.g., in a ratio of from 10:1 to 30:1.

U.S.P. 2,436,568. Hydrocarbon Synthesis. L. I. Griffin and C. E. Jahnig to Standard Oil Development Company.

In the synthesis of hydrocarbons from carbon oxides and H_2 catalyst is suspended in a mixture of these gases. Catalyst containing a waxy contaminant is withdrawn from the reaction zone and washed with a solvent for this contaminant, e.g., with light hydrocarbons. A slurry of catalyst and solvent withdrawn from the washing zone is stratified by the addition of water, the washed catalyst entering the water phase. The thus purified catalyst is returned to the reaction zone in the form of a water slurry.

U.S.P. 2,436,600. Production and Concentration of Butadiene. E. D. Reeves to Standard Oil Development Company.

In the dehydrogenation of n-butene to form butadiene, the effluent of the reaction zone is combined with fresh feed stock and then introduced into an absorbing zone. A preferential solvent for butadiene and n-butene, such as an aqueous monomethylamine solution, is introduced into this zone. Isobutylene formed as a by-product in the reaction is thus separated and is withdrawn from the absorbing zone. The solution containing butadiene and n-butene is stripped to separate the n-butene which is recycled. The butadiene is recovered from the solution.

U.S.P. 2,436,616. Dehydrogenation Proc-

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The 2,000,000-volt x-ray machine shown at left in the photograph above is the newest and largest of twelve similar machines used by B&W to make certain that welded seams in heavy steel pressure vessels meet industry code specifications. Largest ever constructed for inspecting welds, this newest unit is eight times as powerful as the average hospital x-ray.

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ess. S. D. Sumerford to Standard Oil Development Company.

A mono-olefin with at least 4 C atoms, e.g., butene, or a benzene hydrocarbon with at least 2 C atoms in an alkyl substituent group, e.g., ethyl benzene, is dehydrogenated by contacting the hydrocarbon to be treated admixed with steam at a temperature of 1100-1400° F., with a catalyst containing as the active component an iron group metal oxide promoted by a smaller amount of potassium chromate. Butadiene or styrene can, for example, be produced by this process. MgO can be employed as the catalyst support.

U.S.P. 2,436,721. Method of Dehydrogenating Butane. K. C. Laughlin and H. J. Ogorzaly to Standard Oil Development Company.

Butane is contacted under suitable conditions with a body of fluidized powdered dehydrogenation catalyst. Fouled catalyst is withdrawn from the reaction zone and regenerated while still in the fluidized state by a gas containing free oxygen. The regeneration is conducted under conditions such that the regeneration fumes from the regeneration zone always contain less than 10 percent by volume of CO_2 Butylenes are obtained.

U.S.P. 2,436,938. Method of Producing Motor Fuel. W. G. Scharmann and F. T. Barr to Standard Oil Development Company.

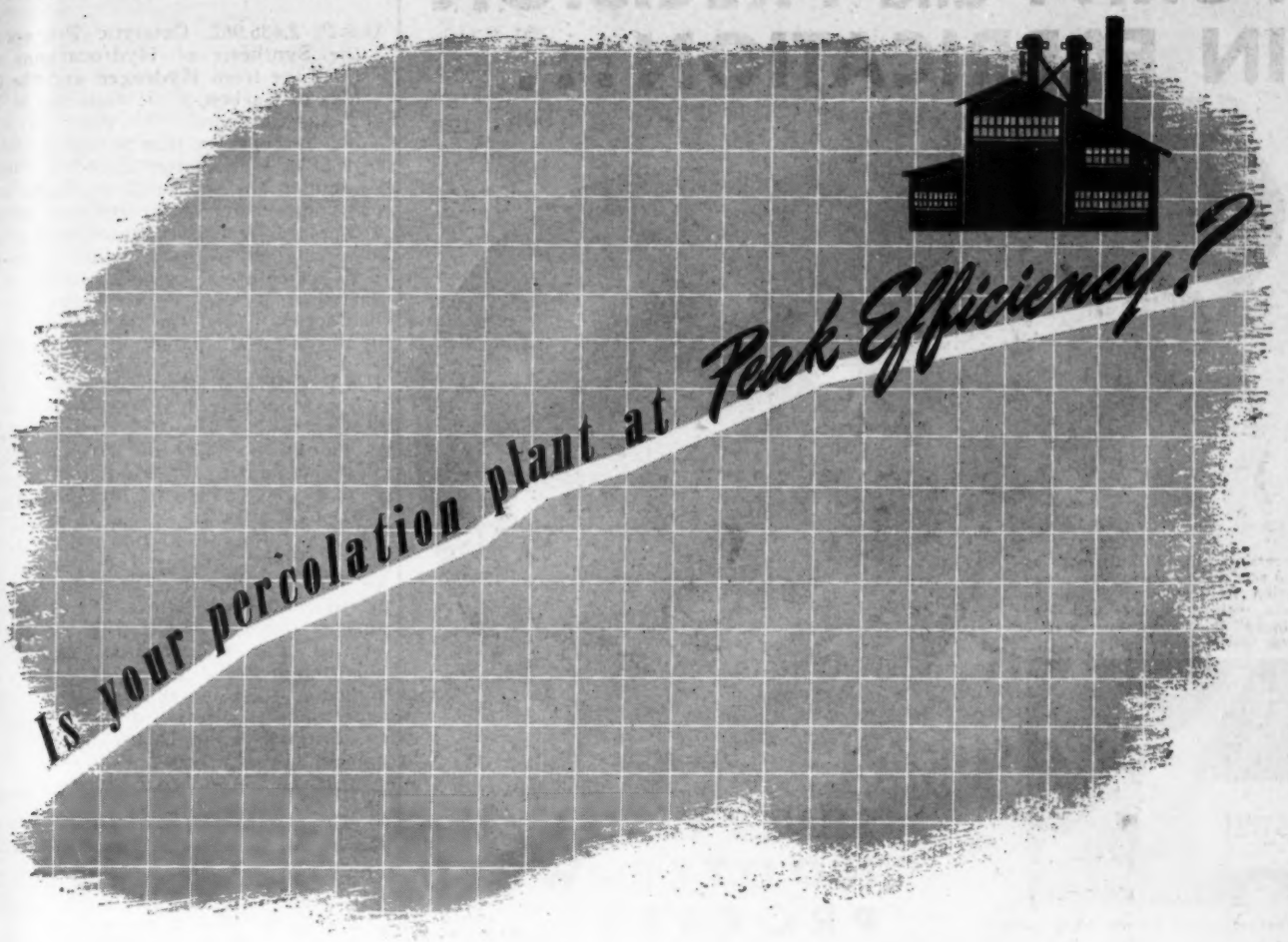
Liquid motor fuels are produced from powdered coal suspended in a hydrocarbon oil free of cyclic hydrocarbons and having an end b.p. of 700-800° F. Details of the process are described and claimed which include coking of the coal by distillation extraction of hydrocarbons, producing a mixture of CO and H_2 by a water-gas process from the coke, synthesizing liquid hydrocarbons from this gas mixture and using the synthesized hydrocarbons after removal of cyclic hydrocarbons as suspension medium for the powdered coal. Liquid motor fuel is continuously recovered from the distillate obtained in the treatment of the coal-oil suspension.

U.S.P. 2,436,932. Production of Polycyclic Hydrocarbons. W. J. Mattox to Universal Oil Products Company.

A charging stock comprising monoethylbenzene is reacted at a temperature of 525-700° C. and an hourly liquid space velocity of 0.1-3.0 in the presence of a synthetic catalyst comprising silica and at least one of the oxides of Al, Th or Zr. Naphthalene is obtained.

U.S.P. 2,436,957. Catalytic Synthesis of Hydrocarbons with Controlled Recycle of Carbon Dioxide. D. B. Eastman to The Texas Company.

In the Fischer-Tropsch Synthesis of hydrocarbons and oxygenated hydrocarbons from CO and H_2 the normally gaseous constituents of the reaction effluent are separated from the noramlly liquid hydrocarbons formed. The gases are divided into a major and a minor stream of which the latter comprises the net production of gaseous reaction products. The major stream which can contain gaseous paraffinic and olefinic hydrocarbons is recycled to the reaction zone. CO_2 is separated from the minor stream and recycled at least in part to the reaction zone. The olefins left in the



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Recently our Technical Staff completed a theoretical analysis of this subject. The report is entitled "The Optimum Point of Discard For Percolation Adsorbents". Here, in concise form, is presented not only a carefully considered basis for determining this important factor, but also general formulae applicable to any percolation operation.

In keeping with our constant aim to be of service to the industry, we are offering copies of this report to petroleum refiners. A request will bring a free copy by return mail.

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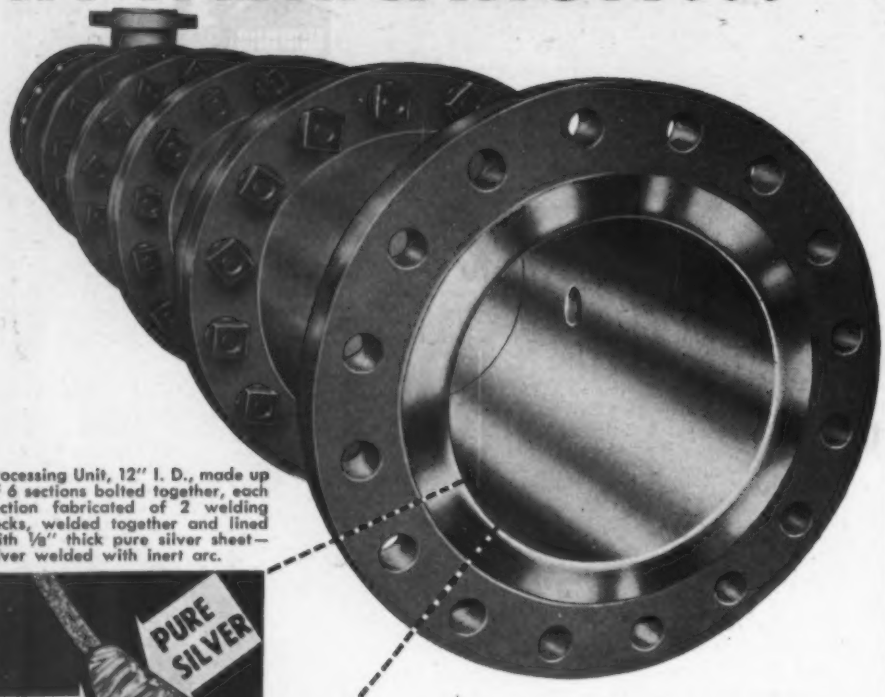


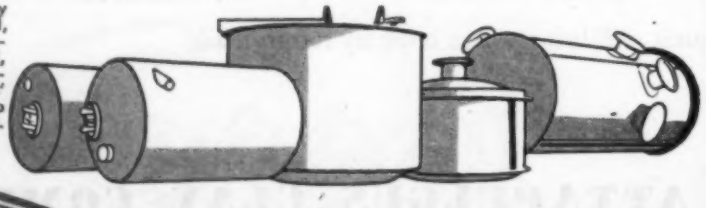
Processing Unit, 12" I. D., made up of 6 sections bolted together, each section fabricated of 2 welding necks, welded together and lined with ⅛" thick pure silver sheet—silver welded with inert arc.

Cross-section of Nooter-Weld before Grinding and Burnishing.

SILVER CLAD by the NOOTER-WELD PROCESS.....

Here's a good example of how the Nooter-Weld combines the properties of two entirely different metals — *heavy duty middle gauge steel* for pressure resistance and structural strength—with a pure silver for corrosion-resistance. The Nooter-Welds of the silver inert arc type (invisible because they are ground and buffed) are used for bonds and seam-welds. The steel is built up to pure silver without any dilution from the vessel wall to which it is bonded. This is essential to corrosion-resistance and to the successful performance of the unit. Nooter craftsmanship can always be identified by distinctive construction features—such as smooth, straight seam-welds—placement of fillets, etc., as well as precise fit-up.

Processing Equipment by Nooter—Converter Shell, 6'6" diam. 19'5" long—Hot Gas Filter Shell, 7'6" diam. 5'8" long—Sulphur Burner Shell, 8' diam. 17' long—Pump Tank, 9' diam. 6' long.



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minor stream can be polymerized to increase the yield of liquid hydrocarbons.

U.S.P. 2,436,962. Catalytic Process for the Synthesis of Hydrocarbons and the Like from Hydrogen and the Oxides of Carbon. L. P. Gaucher to The Texas Company.

The process of this patent is similar to that of U. S. patent 2,436,957. Olefins present in the separated normally gaseous components of the reaction effluent are polymerized by contact with a suitable catalyst to form liquid hydrocarbons which are separated from the residual gases. The gases are treated in the manner indicated for the effluent gases in the aforesaid patent.

U.S.P. 2,437,051. Hydrogenation of Carbon Monoxide. E. E. Sensel and R. A. Beck to The Texas Company.

A mixture of CO and H_2 is contacted at a temperature of 392-450° F. with a solid catalyst consisting of a major proportion of metallic CO in mixture with ThO_2 and Na_2CO_3 in an amount of 0.55-2.85 percent Na based on the weight of the CO, supported on a siliceous supporting material. The contact temperature is correlated with the Na content of the catalyst in such a manner that this temperature is higher within the indicated range as the amount of Na is increased. A maximum production of unsaturated liquid hydrocarbons is obtained by this process.

DESULFURIZATION

U.S.P. 2,435,732. Refining Hydrocarbon Liquids. G. W. Ayers and P. Lyon to The Pure Oil Company.

Elemental S and organic polysulfides containing more than 2 S atoms per molecule are removed from hydrocarbon liquid by contacting this liquid with alkali metal stannite solution. The mercaptans formed from the polysulfides by this treatment can then be removed in the usual manner. The spent stannite solution can be regenerated by contacting it with Mg.

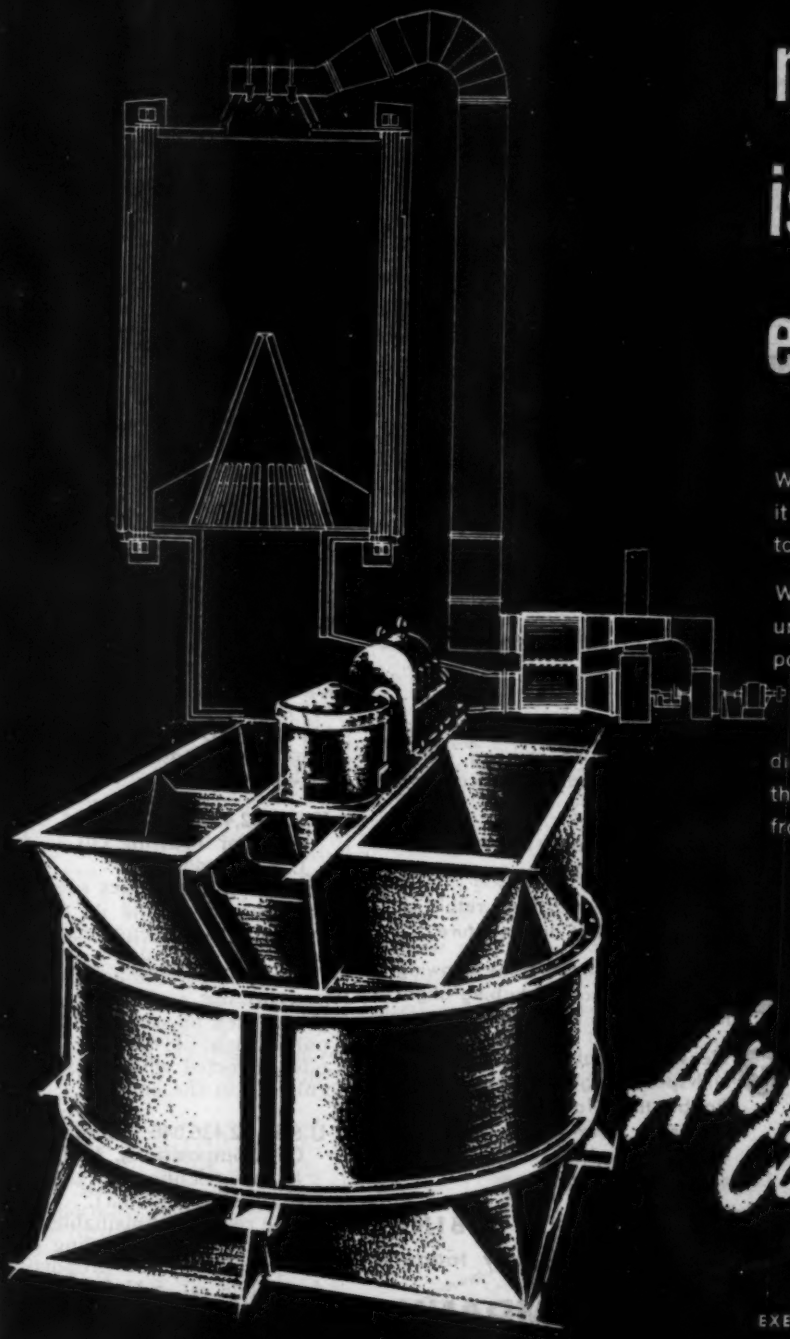
U.S.P. 2,436,494. Method for Treating a Hydrocarbon Feed Stock with a Solution of Toluene Sulphonic Acid and Sodium Meta Arsenite. G. H. Shipley, Jr., and G. W. Wilson, Jr., to Standard Oil Development Company.

A hydrocarbon feed stock is contacted at a temperature of 100-400° F. with a solution comprising a major portion of aryl sulfonic acid, e.g., toluene sulfonic acid, and a minor portion of sodium meta arsenite dissolved in an organic solvent. 0.0013-0.013 gram moles of the arsenite can, for example, be employed per 100 grams of the solution. Such treatment can remove sulfur from the hydrocarbons, can enhance their octane number and improve their color. Olefins can be removed from toluene and the like.

U.S.P. 2,436,565. Lubricating Oil. D. B. Gillett to Standard Oil Development Company.

The lubricant according to this patent comprises a major portion of wax-free oil in the lubricating oil range separated from a paraffin base crude petroleum, a minor portion of wax separated from a naphthenic base crude petroleum, and a minor portion of the condensation product formed by condensing chlorinated

when high heat recovery is essential



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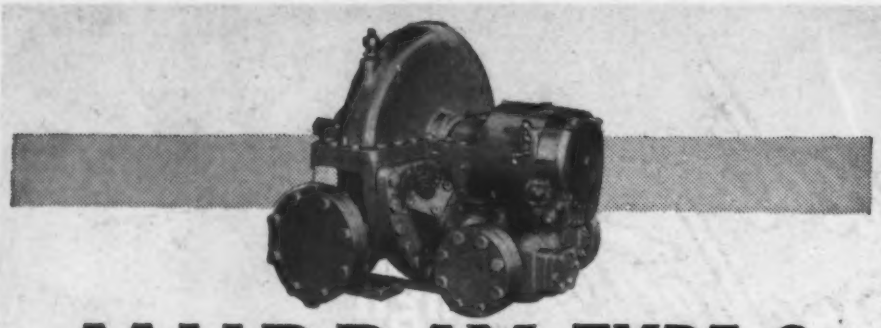

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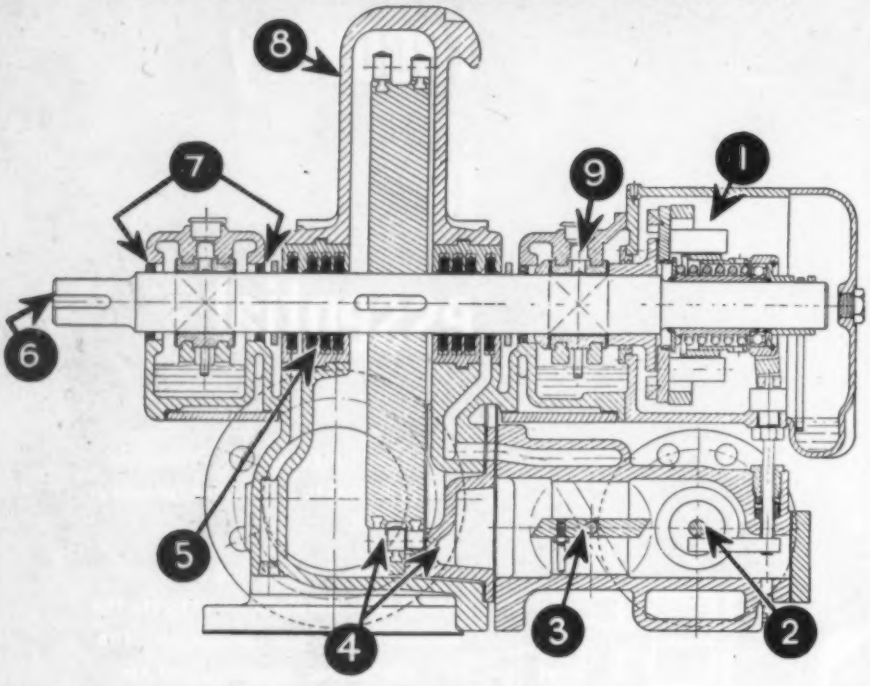

1. Mechanical constant speed governor completely enclosed and fully lubricated. Heavy cast housing, removable for inspection. Provision for tachometer reading, by removing end plug.
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3. Separate emergency overspeed butterfly trip valve actuated by unbalanced weight type emergency overspeed governor.
4. Stainless steel blading and shroud band. Nozzles drilled and reamed in replaceable nozzle ring.
5. Carbon ring glands, stainless steel springs, corrosion resisting gland cases. Cast in leakoff reduces pipe fittings necessary.
6. Tapped hole in shaft end facilitates drawing on coupling.
7. Bearing seals effectively retain oil and exclude dirt and moisture.
8. Casing split at centerline allowing inspection without disturbing alignment or steam connections.
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paraffin wax with an aromatic hydrocarbon. The composition is particularly adapted for use as a lubricant in internal combustion engines subjected to extreme cold. It can be diluted with naphtha.

U.S.P. 2,436,550. Desulfurization of Tri-isobutylene. R. C. Brandon to Standard Oil Development Company.

Polymerized isobutylene, particularly tri-isobutylene, is desulfurized to a S content of less than 0.01 percent by treating it in the liquid phase with a dehydrated alumina (e.g., bauxite) containing no more than 3 percent water.

HEAVY OILS AND WAXES

U.S.P. 2,435,619. Lubricant Compositions. D. W. Young and W. J. Sparks to Standard Oil Development Company.

The composition according to this patent comprises a major proportion of mineral lubricating oil and about 0.1-10 percent of a polyester condensation product formed from a dicarboxylic acid or a lower aliphatic ester thereof and a glycol. At least one of the monomeric substances employed in the formation of the condensation product shall have at least 10 C atoms, and this product shall be completely soluble in paraffin oil, shall have a viscosity index of at least 100 at 30° F. and shall be free from polyester fractions which are less soluble in the paraffin oil. The polyester condensation product of methyl dilinoleate and decamethylene glycol can, for example, be used for this purpose.

U.S.P. 2,435,655. Lubricant. H. D. Rhodes, G. F. Rouault, and C. N. White to Standard Oil Company (Indiana).

The oxidation stable and rust inhibiting composition according to this patent comprises a major proportion of a hydrocarbon oil, 0.001-0.1 percent of a beta-naphthol, 0.001-3 percent of N-phenyl-alpha-naphthylamine, 0.0005-0.5 percent of stearic acid, and 0.0005-1 percent naphthenohydroxamic acid. The composition can be used as a lubricant or a turbine oil.

U.S.P. 2,435,707. Method of and Apparatus for Treating Oil. U. B. Bray and J. K. Russell.

Colloidal impurities produced in a lubricating oil during its use in an internal combustion engine or the like are removed by adding a non-aqueous slightly oil-soluble agglomerating amino soap to the contaminated oil. The agglomerated masses are filtered out. This purification of the oil can be continuously effected while it is in use and circulating in the engine.

U.S.P. 2,436,046. Emulsifiable Soluble Oil Compositions. N. E. Lemmon and F. W. Schuessler to Standard Oil Company (Indiana).

The readily emulsifiable liquid soluble-oil composition according to this patent comprises a major proportion of a hydrocarbon oil, 5-11 percent of a sodium soap of a preferentially oil-soluble petroleum sulfonic acid with a mol wt. of 450-550, which soap is normally unsuitable for use in soluble-oil compositions, 0.5-10 percent of a water-soluble alkylated ar. hydrocarbon sulfonate the alkyl substituents of which contain 9-17 C

atoms in the side chain, and 1-3 percent water. Petroleum sulfonic acids can be employed for this purpose which are obtained in the treatment of petroleum oils with sulfonating agents, such as conc. or fuming H_2SO_4, and have the mol. wt. indicated above.

U.S.P. 2,435,734. Method of and Apparatus for Filtering Oil. U. B. Bray and J. K. Russell.

The method for purifying lubricating oil from contaminants formed described in this patent is similar to that of U. S. patent 2,435,707. An amino soap of castor oil fatty acids can, for example, be employed for agglomerating the impurities.

U.S.P. 2,436,051. Lubricant. L. W. Mixon to Standard Oil Company (Indiana).

The lubricant composition according to the patent comprises a major proportion of a hydrocarbon oil and 0.05-10 percent of a zinc alkyl trithiocarbonate or a zinc alicyclic trithiocarbonate. The terpenyl and the keryl trithiocarbonate are examples of the compounds the zinc salts of which are useful here. Oxidative deterioration of the lubricant during use is inhibited by the additive.

U.S.P. 2,436,272. Mineral Oil Composition. G. H. S. Snyder, R. V. White, J. H. Bishop, and J. F. Socolofsky to Socony-Vacuum Oil Company, Inc.

The composition according to this patent comprises a viscous mineral oil mixed with a minor proportion of an ester product of malic acid obtained by reacting 1 mol equivalent of malic acid with 0.8-1.6 mol equivalents of an aliphatic alcohol with 6-8 C atoms and with 1.2-0.4 mol equivalent of an aliphatic alcohol with 12-18 C atoms. Rusting of ferrous metal surfaces in the presence of water is retarded by this additive to the mineral oil. A suitable material representative of the first type of alcohols used in the preparation of the additive is 2-ethyl hexyl alcohol and examples for the second type are oleyl alcohol, octadecyl and hexadecyl alcohol.

U.S.P. 2,436,589. Compounded Lubricated Oil. J. P. McDermott to Standard Oil Development Company.

The mineral lubricating oil according to this patent contains an oxidation-inhibiting amount of zinc isopropyl xanthate (e.g. 0.02-1 percent).

PETROCHEMICALS

U.S.P. 2,434,510. Condensation of Olefinic Compounds with Hydrogen Sulfide. J. F. Olin and J. L. Eaton to Sharples Chemicals, Inc.

An open chain olefin is condensed with H_2S by means of a catalyst consisting of BF_3, HF, $AlCl_3$, $BeCl_2$, $FnCl_2$, BCl_3, PF_5, AsF_5, $SnCl_4$, $TiCl_4$, or SbF_5 at a reaction temperature below 100° C. Mercaptans are formed which have the sulfhydryl radical attached to a non-terminal C atom, e.g., tert. dodecyl mercaptan from triisobutylene. Tertiary olefins which have 8-20 C atoms in the molecule are preferably used, and the treating temperature can be below 0° C.

U.S.P. 2,434,662. Polyethylene Stabilized with Bis-(Hydroxyphenyl) Propanes. G. H. Latham and D. E. Strain to E.

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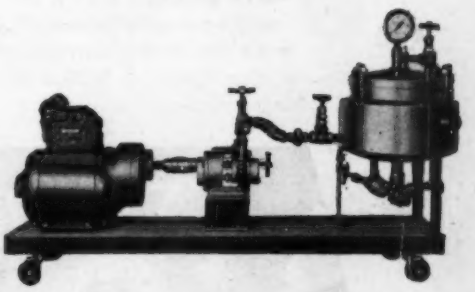

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I. du Pont de Nemours & Company. The product according to this patent comprises normally solid ethylene homopolymer and 00.1-5 parts by weight of diphenylol propane or dicresylol propane. The product has improved stability.

U.S.P. 2,435,570. Nitrosyl Halide Addition Product of Allyl-Type Olefinic Hydrocarbons. L. J. Beckham to Allied Chemical & Dye Corporation.

One mol. of olefinic hydrocarbon with at least 12 C atoms, one alphatic —C=C— linkage and not more than one ring system, said linkage being in a $-CH_2CH=CH_2$ radical, is reacted with at least one-half mol. of nitrosyl chloride or bromide at a temperature of —20° to 80° C. An addition product is formed. The resulting products are useful as starting materials in the synthesis of products having surface-active properties. Waxes obtained as by-products in the Fischer-Tropsch synthesis, cracked paraffin waxes, or cracked topped petroleum crudes can, for example, be employed as the olefinic charge material.

U.S.P. 2,435,674. Butadiene-1,3-Ethyl Alpha Phenylacrylate Copolymer. A. M. Clifford to Wingfoot Corporation.

An aqueous emulsion of a mixture of 60 parts of butadiene-1,3 and 40 parts of ethyl alpha-phenylacrylate is polymerized to form a rubber-like plastic mass.

U.S.P. 2,435,763. Hydrogen Bromide Catalyzed Oxidation Reactions. W. E. Vaughan and E. R. Bell to Shell Development Company.

Organic peroxides, such as di(tertiary butyl) peroxide, are obtained by reacting an organic compound which contains at least one tert. C atom of aliphatic character and wherein a replaceable H atom is directly attached to the tert. C atom, e.g. isobutane, with oxygen in the presence of HBr at elevated temperature. The effluent reaction mixture formed and containing organic peroxides and bromides is contacted with an olefin, e.g. propylene, in order to bind the bromine and render it innocuous.

U.S.P. 2,435,773. Butadiene-Acrylonitrile Copolymer Plasticized with Isobutyl Beta Isobutoxy Propionate. A. M. Clifford and J. G. Lichty to Wingfoot Corporation.

The patent relates to a rubber-like copolymer of butadiene and acrylonitrile plasticized with isobutyl beta isobutoxy propionate.

U.S.P. 2,435,790. Cyanostyrene Copolymerized with Butadienes. J. R. Long to Wingfoot Corporation.

The patent covers copolymers of from 20-80 percent of butadiene-1,3, isoprene, or 2,3-dimethyl-butadiene-1,3, and from 80-20 percent of o—, m—, or p-cyanostyrene.

U.S.P. 2,435,983. Production of Liquid Hydrocarbons. L. Schmerling to Universal Oil Products Company.

A monohaloalkane and a mono-olefin, such as ethylene, are reacted in the presence of a phosphoric acid catalyst at suitable conditions, e.g. at a temperature of 500-750° F. Liquid mono-olefins are obtained.

U.S.P. 2,436,058. Production of Alkyl Cycloalkyl Halides. L. Schmerling to

Universal Oil Products Company.

A tertiary alkyl halide, such at tert. butyl chloride, and a cyclo-olefin, such as cyclohexene, are condensed in the presence of a Friedel-Crafts metal halide catalyst at a temperature of —40° to +50° C. Alkyl cycloalkyl halides, such as tert. butyl cyclohexyl chloride, are obtained.

U.S.P. 2,436,069. Oils and Greases Obtained by Pyrolysis of Tetrafluoroethylene-Olefin Copolymers. R. M. Joyce, Jr., to E. I. du Pont de Nemours & Company.

A normally solid copolymer of tetrafluoroethylene and a mono-olefinic hydrocarbon with 2-4 C atoms are heated in an inert atmosphere at a temperature of 400-700° C. until an oil to grease like product is obtained which has a percentage of unsaturation of at least 25. The copolymer can contain 10-60 mol. percent of tetrafluoroethylene.

U.S.P. 2,436,213. Synthetic Rubberlike Materials Comprising Fluoroprene. F. B. Hill, Jr., to E. I. du Pont de Nemours & Company.

The rubber-like material according to this patent is obtained by copolymerizing a mixture of 15-80 percent of fluoroprene, 80-15 percent of 1,3 butadiene, and 5 percent of a vinylidene compound, such as styrene, dimethyl vinylethynyl carbinol, or butyl methacrylate.

U.S.P. 2,436,269. Preparation of Alpha, Omega-Dicarboxylic Acids. S. L. Scott to E. I. du Pont de Nemours & Company.

Normally solid polymers obtained by polymerization of CO with ethylene are treated with HNO_3 of 25-75 percent concentration at a temperature of at least 50° C. A vanadium salt or the like can be added as an oxydation catalyst. Alpha, omega-dicarboxylic acids are obtained.

U.S.P. 2,436,366. Process for Chlorination of Hydrocarbons. J. S. Sconce and A. N. Johnson to Hooker Electrochemical Company.

Paraffinic hydrocarbons of 3-7 C atoms are transformed into trichlorides substantially free from decomposition and secondary reaction products by first continuously forming, in darkness and at a temperature below 120° C. a mixture of gaseous Cl_2 and a vaporized hydrocarbon with an excess of Cl_2 over the range within which such mixtures when activated, react violently. This mixture is passed in vigorous flow through a reaction zone irradiated by actinic light. Heat is simultaneously withdrawn to limit the rise of the reaction temperature to a maximum of 200-400° C. The reaction mixture is then continuously deactivated by passing it through a darkened zone where it is cooled to below 120° C. More of the hydrocarbon is continuously added to the deactivated mixture which is then again treated by the actinic light to yield more of the trichloride.

U.S.P. 2,436,456. Hydrocarbon Resin-Sulfurized Oil Composition. F. J. Soday to The United Gas Improvement Company.

The composition comprises a mixture of 10-90 percent of a sulfurized oil with 90-10 percent of a resin resulting from the polymerization of hydrocarbons contained in an hydrocarbon oil of particular properties which has been physically

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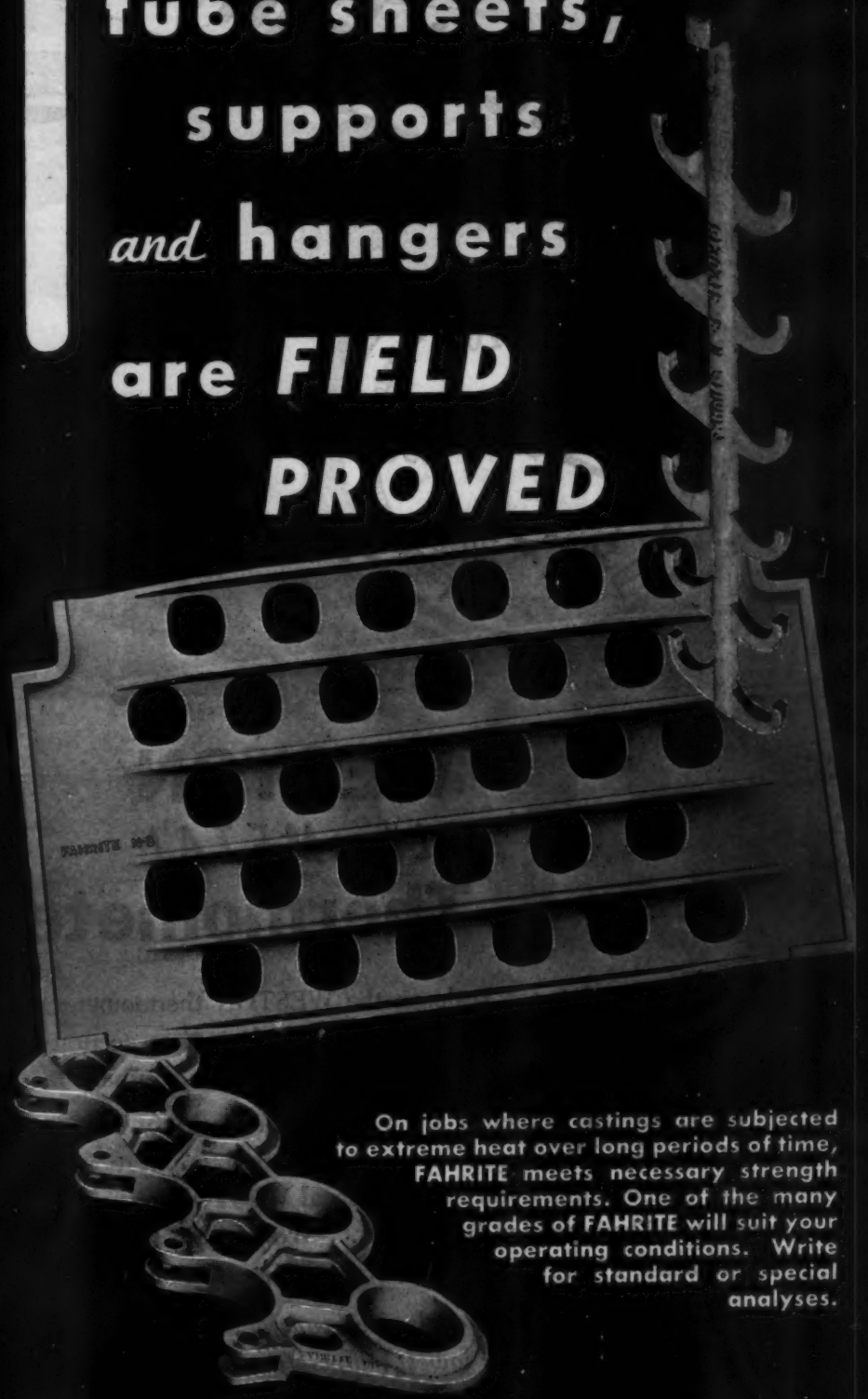
tube sheets, supports *and* hangers are FIELD PROVED



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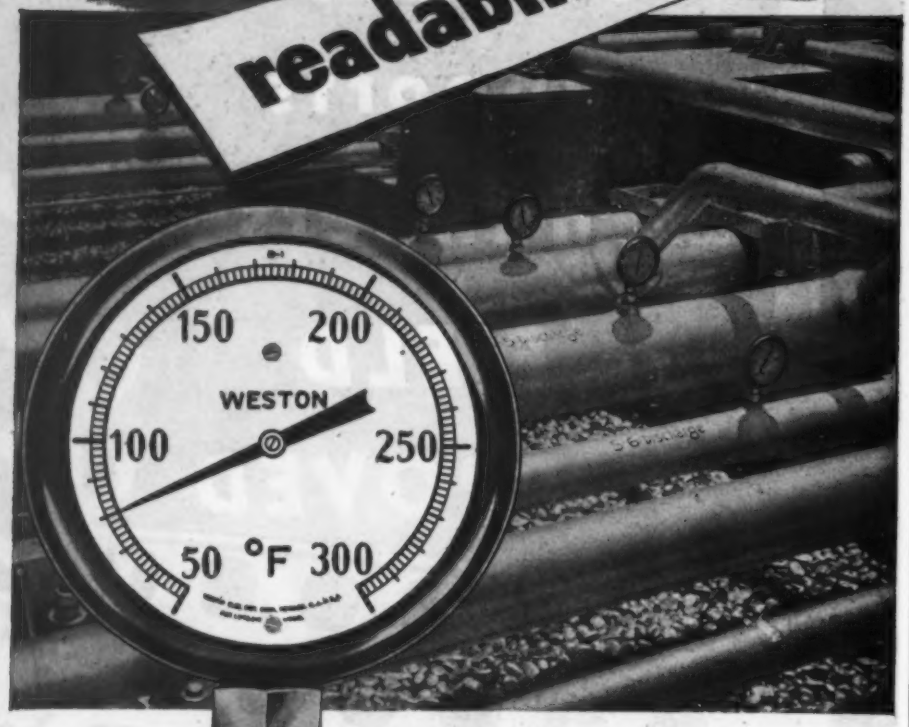

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MAX-MIN models also available to indicate highest or lowest temperature reached.

Weston *Instruments*

separated from tar produced in the vaporphase pyrolysis of petroleum oil.

U.S.P. 2,436,457. Sulfurized Oil—Aromatic Oil Compositions. F. J. Soday to The United Gas Improvement Company.

The composition according to this patent is similar to that of U.S. patent 2,436,456. In the present case the tar employed was produced by vapor phase pyrolysis of petroleum oil at temperatures above 1300° F., and the hydrocarbon oil employed boils above 210° F., is free from pitch, has an aromatic hydrocarbon content of at least 95 percent and is free from resin-forming material polymerizable by heat alone.

U.S.P. 2,436,490. Production of Monohalocycloalkanes. L. Schmerling to Universal Oil Products Company.

A cycloparaffinic or naphthenic hydrocarbon, such as alkyl cyclo-pentane or -hexane, is reacted with a halo-olefin, e.g. with allyl chloride, in the presence of a Friedel-Crafts metal halide catalyst at a temperature of —30° to +25° C. Halonaphthenic hydrocarbons or halocycloalkanes are obtained.

U.S.P. 2,436,491. Method of Producing a Cyclo-Olefin. I. Schmerling to Universal Oil Products Company.

According to this patent the products obtained by the process of U.S. patent 2,436,490 are subject to dehydrohalogenation to form an unsaturated compound.

U.S.P. 2,436,591. Process for Making Olefin Chlorhydrins. C. E. Morrell, J. K. Small, and H. L. Yowell to Standard Oil Development Company.

An olefin is reacted with Cl in the presence of an aqueous solution of H_2SO_4 containing 20-80 percent acid. HCl formed is separated from the reaction mixture, whereupon the resulting olefin chlorhydrin is separated at a temperature below its decomposition temperature. The reaction temperature can, for example, be between the freezing point of the reaction mixture and 50° C.

U.S.P. 2,436,641. Preparation of an Alkyd Type Resin. H. L. Gerhart and L. M. Adams to Pittsburgh Plate Glass Company.

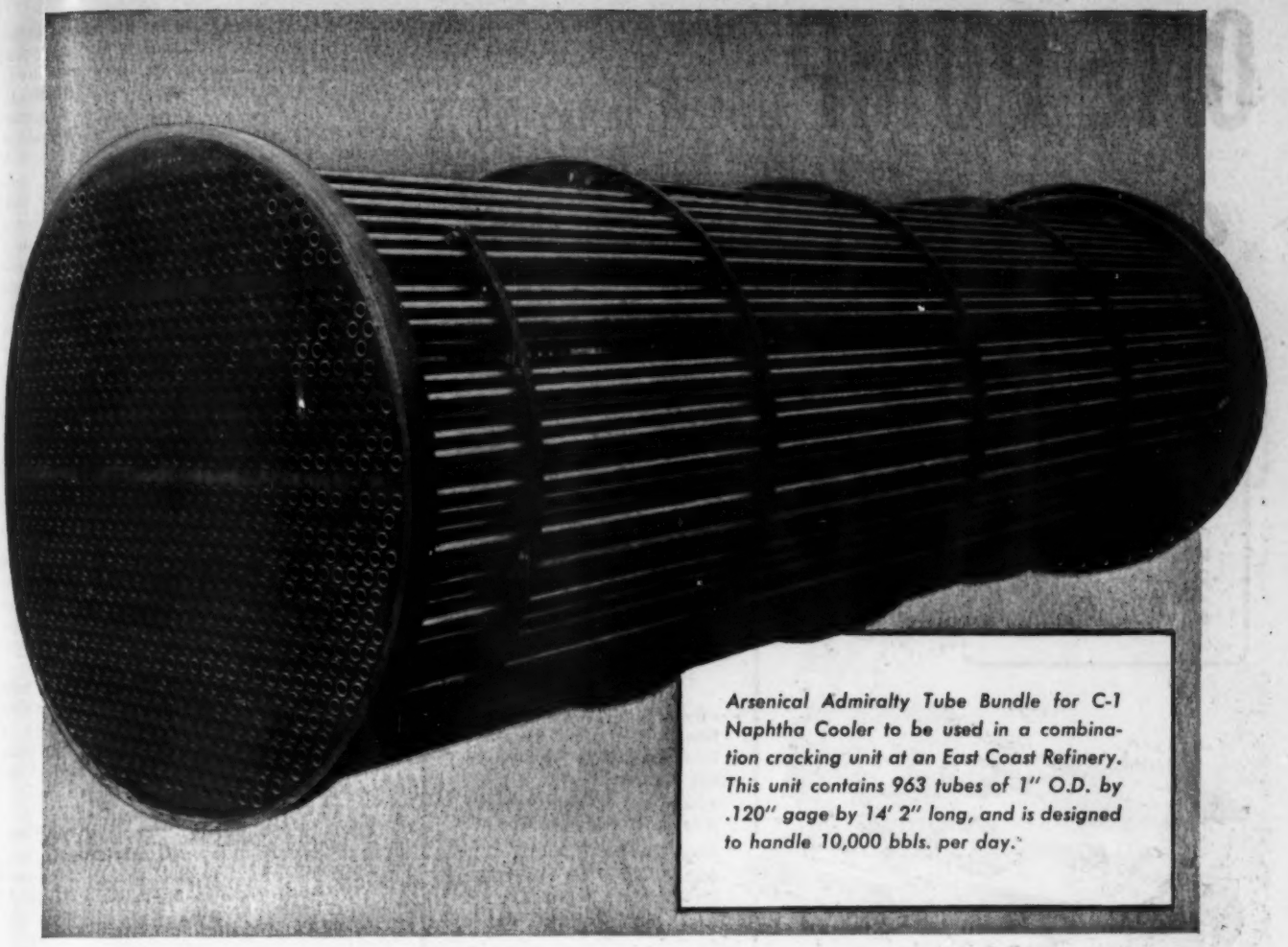
A mixture of dicyclopentadiene, maleic anhydride and a mono-or diglyceride of a drying oil acid mixed, if desired, with glycerol is heated in a closed system to an initial temperature of 180-200° C. and then to about 210° C. until an alkyd resin is formed.

U.S.P. 2,436,864. Dehydration Process. R. Johnson to Koppers Company, Inc.

Tetralin is oxidized with air at atmospheric pressure. The resulting tetralin peroxide is treated with an alkali-metal hydroxide. The mixture of alpha tetralol and alpha tetralone formed is hydrogenated over a $CuO\text{-}Cr_2O_3$ catalyst. The hydrogenated mixture is distilled to separate alpha tetralol. This tetralol is passed in vapor state over an alumina-bearing catalyst at a temperature of 290-350° C. 1,2-dihydronaphthalene is thus produced.

U.S.P. 2,436,923. Demethylation of Hydrocarbons in Presence of Water. V. Haensel to Universal Oil Products Company.

A paraffinic hydrocarbon with more



Arsenical Admiralty Tube Bundle for C-1 Naphtha Cooler to be used in a combination cracking unit at an East Coast Refinery. This unit contains 963 tubes of 1" O.D. by .120" gage by 14' 2" long, and is designed to handle 10,000 bbls. per day.

ARSENICAL ADMIRALTY...
for refinery heat transfer equipment

SINCE 1934, Anaconda Arsenical Admiralty Tubes have been gaining acceptance . . . and preference . . . for a wide variety of refinery heat exchanger equipment.

Tubes of this alloy are effectively resistant, under normal conditions, to corrosion encountered in crude and re-run stills, in cracking and polymerization plants producing oils, and in the manufacture of by-products. Its arsenic content fortifies it against dezincification.

Arsenical Admiralty is just one of 11 standard and special alloys which The American Brass Company regularly furnishes in seamless tube form for heat exchanger applications. All such tubes are subjected to precision control through every step of manufacture.

Equipment manufacturers are invited to use the broad experience and metallurgical knowledge of our Technical Department in determining the most suitable alloys for their requirements. Publication B-2, providing comprehensive information on Anaconda Tubes and Plates for Condensers and Heat Exchangers, will be mailed on request.

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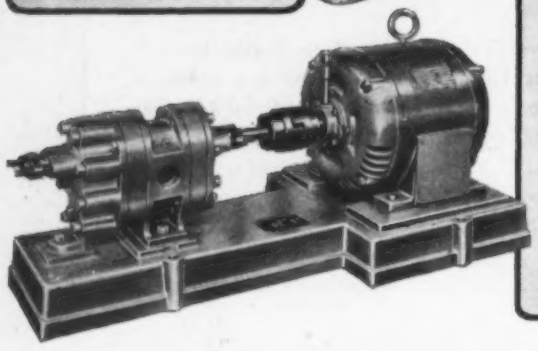
ONE PUMP working on the job is *worth a dozen* in the repair shop!

SIER-BATH SCREW PUMP

Advantages: • pulseless flow • anti-friction bearings • vibrationless operation • low maintenance cost • rugged construction.

Pumps: Acetate, asphalts, brines, Bunker C Fuel Oil, Cellulosics, Greases, Molasses, Syrups, Lube Oils, etc.



SIER-BATH GEAREX PUMP

• Balanced Axial Thrust • Pulseless Flow • Vibrationless Operation • Roller Bushings for Precision Running under load.

Pumps: Oils, Varnishes, Solvents, Molasses, Chemical Solutions.

Capacities: 1-550 g. p. m.

Discharge: 250 p. s. i. for medium or high viscosities. 50 p. s. i. for water.

The most notable point about SIER-BATH Screw Pumps and Gearex Pumps is their relative freedom from maintenance.

THERE is no mystery about the ability of Sier-Bath Pumps to stand up under the most trying conditions. After all, in such pumps, the worms and gears are the most important parts. And when you consider that Sier-Bath Pumps are made in the best equipped precision gear shop in the country, it is easy to understand their exceptional dependability. Their pulseless flow and vibrationless operation greatly reduce maintenance cost—there is much less wear on valves, couplings and other fittings. Pipes and joints remain tight. With labor costs at their present high figures, these are important points to consider in pump selection. Send for descriptive booklet.

ALSO MAKERS OF SIER-BATH PRECISION GEARS

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Sier-Bath GEAR and PUMP CO., Inc.

9249 HUDSON BOULEVARD • NORTH BERGEN, NEW JERSEY

than 4 C atoms is mixed with 2-12 molecular proportions of water per mol. proportion of hydrocarbon. The mixture is reacted at a temperature of 180-350° C. in the presence of an active hydrogenation catalyst comprising a metal of group VIII of the periodic table with an atomic number of at least 27, such as Ni or Co. A paraffin of lower mol. wt. is obtained, e.g. neopentane from a paraffin with at least 6 C atoms and a quaternary C atom, or triptane from a paraffin with at least 8 C atoms and vicinal ternary and quaternary C atoms. Olefins, alkyl aromatics, and saturated alkyl hydroaromatics can be used as the charge materials instead of the paraffins.

U.S.P. 2,436,710, 2,436,711. Preparation of Vinyl Chloride. J. A. Bralley to The B. F. Goodrich Company.

According to patent 2,436,710 acetylene is reacted with HCl or another halogen halide in the vapor phase in the presence of a trivalent arsenic compound in which at least one valence of the arsenic is satisfied by a beta-halovinyl group while the remaining valences are satisfied by Cl. A surface active carrier for this catalyst, e.g. activated charcoal, is employed.

According to U.S. patent 2,436,711 the catalyst used comprises a bivalent mercury compound the valences of which are satisfied in the same manner as in the arsenic compound. Vinyl halides are obtained in both cases.

U.S.P. 2,437,148. Preparation of Fluorine Hydrocarbon Compounds. A. L. Barney to E. I. du Pont de Nemours.

A mixture of an acetylenic hydrocarbon, such as monovinyl acetylene, with HF is contacted at a temperature of 20-150° C. with a catalyst consisting of HgO at least partially combined chemically with an oxide of nitrogen (e.g. as Hg $(NO_3)_2$) supported on a water-insoluble alkaline earth metal salt unreactive with HF, such as a a sulfate, fluoride, or phosphate, as a carrier. This catalytic composition is obtained by roasting a mixture of a thermally-decomposable Hg compound with the alkaline earth metal salt at temperatures of 95-400° C. until the moisture content is below 2 percent. Vinyl fluorides, e.g. fluoroprene are thus synthesized.

U.S.P. 2,437,231. Copolymers of Styrene and a Beta-Cyanoacrylate. D. T. Mowry to Monsanto Chemical Co.

A mixture of styrene and 1-50 percent by weight of the mixture of a compound of the formula

$$R.C{:}CX.CO_2Y$$
$$\quad\quad\quad

TIES

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Not that you could build a refinery or a chemical plant by telephone . . . but it does serve to illustrate the control Graver maintains in any construction job. It's a control over every phase of the operation from blueprint to test run.

The Graver Construction Company is prepared *now* to assume the entire responsibility for your next job whether it is merely a matter of new equipment installation or a complete refinery. Graver's engineers, supervisory personnel and equipment (located at several depots in the oil producing areas of the country) are at your service.

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Other Graver services include the design, fabrication and erection of a complete line of water conditioning equipment and specialized work in steel and alloy plate.

New EQUIPMENT MANUFACTURERS' LITERATURE

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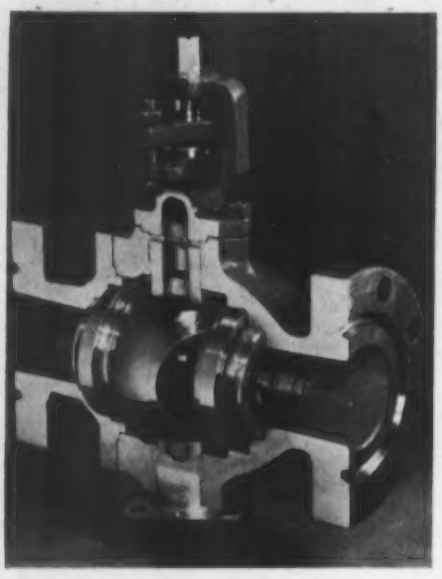
1—"Ball" Valve

Kerotest Manufacturing Company, Pittsburgh 22, Pa. will exhibit at the International Petroleum Exposition its new Kerosphere non-lubricated "ball" valve for high and medium pressure service. The Kerosphere utilizes a spherical ball that absorbs the thrust of line pressures on vertical trunnions and is



sealed by seats which remain in constant contact with the sphere. Full opening or closing is accomplished with a quarter turn. Uniformly easy operation under high pressure, without lubrication, is claimed since the pressure against the spherical ball is absorbed by the trunnions. The seats provide constant seal which also eliminates sediment collection that could cause abraision or galling.

2—Welding Torches

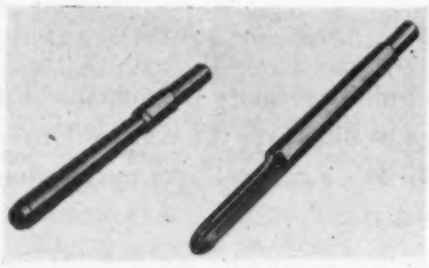
Air Reduction Sales Company, 60 East 42nd Street, New York 17, is including in its exhibit at the International Petroleum Exposition the new Airco 700 and 800 welding torches, these in addition to the complete Airco lines of gas and arc welding equipment, apparatus and supplies, a pipe beveling machine, manual heliwelding equipment and flame hardening equipment and the No. 10 Radiagraph.

3—"Band-It Clamps"

Band-It Clamps, Denver, Colo., will display a complete line of their products at the International Petroleum Exposition. Clamps of any diameter can be formed from one continuous roll of Band-It stainless steel band. One hundred-foot rolls of stainless steel bands and buckles in ⅜, ½, ⅝, and ¾-inch widths handle most every job. Band-It clamps may be used on all types of pressure and suction hose and for repairing leaks in any diameter pipe or tank. Also on exhibit will be the new Band-It "warehouse" which holds 900 industrial pressure clamps, any diameter, in less than one cubic foot of space. Full warehouse also contains bands, buckles, screw lock and screw nut.

4—Knock-Out Tools

The Airetool Manufacturing Company, 316 South Center Street, Springfield, Ohio, is now making knock-out tools for removing tube ends from condensers and heat exchangers when retubing a bundle. These, to be shown at the International Petroleum Expositions consist of a combination collapsing tool and tube drift (pictured on the right) and a tube drift (shown left). The heat treatment that these tools undergo during manufacture provides a uniform grain and hardness in the finished tool that gives long tough service, Airetool claims.



Left, Tube Drift. Right, Combination Collapsing Tool and Tube Drift

Featured in this section for May are many of the pieces of new equipment which will be exhibited in the booths at the International Petroleum Exposition which will be held at Tulsa May 15-22 inclusive.

5—Fuel Oil Filter

A new fuel oil filter that is designed for use on diesel engines, home and industrial oil burners and also for gasoline engines will be shown at the International Petroleum Exposition by Sparkler Manufacturing Company, Mundelein, Ill. It consists of a small pressure tank 4 inches in diameter and 5 inches deep

housing a removable cartridge of horizontal plates between which a very high grade sheet of filter paper is clamped. Advantages cited by the company include "a very fine and uniform quality of filtration (filters down to 2 microns in size), permits low operating cost, replacements occupy very little space and filters are simple and easy to clean."

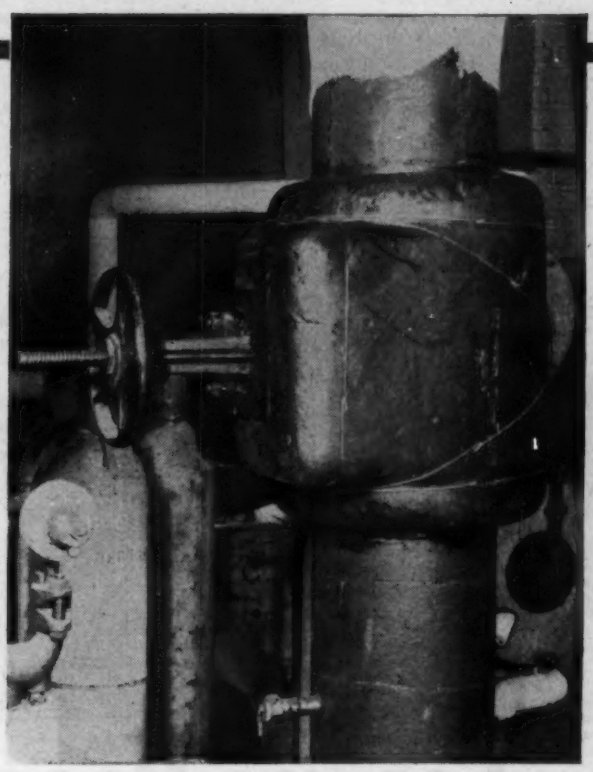
6—Valves

The Lunkenheimer Company, P. O. Box 360, Annex Station, Cincinnati 14, Ohio, will exhibit a complete line of valves at the International Petroleum Exposition. Lunkenheimer's exhibit will include a new line of 125-pound S. P. bronze globe, angle and check valves; a recently developed line of 125-, 150-, and 200-pound bronze gate valves; and a series of bronze globe and angle valves with 500 Brinell-type stainless steel plug seats and discs. The above new products are available in sizes from ¼- to 3-inch.

7—Side Entering Mixer

Mixing Equipment Company, Rochester, N. Y., will exhibit for the first time in the Allan Edwards, Inc., booth, International Petroleum Exposition, the

How to cut the cost of a good cold line covering job



SINCE a large part of the cost of insulating lines today is the time required for installation, labor-saving materials can make an important cash difference. For example, molded cork pipe covering itself is higher in price than wrap-around materials. But cork covering saves so much time that the total cost for installing it is far less.

This difference is particularly marked in the insulation of valves and fittings. Armstrong's factory built cork covers can be completely installed in less than half the time a good wrapping job will take.

Shown here are two steps in applying one of these covers around a flanged valve. After the second section is wired in place, all voids are filled with Armstrong's Fitting Filler, which is easily and quickly poured into place. Armstrong's Fitting Covers are made to fit exactly all standard tees, ells, and valves—both screwed and flanged. They are manufactured in three thicknesses to handle all temperatures from 35° F. to minus 25° F.

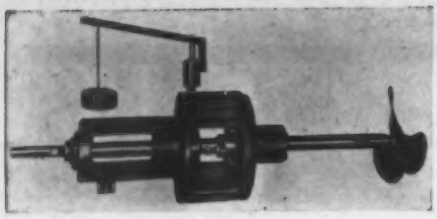
For further information on Armstrong's Cork Covering and Fitting Covers, write today to Armstrong Cork Co., Building Materials Division, 7505 Concord Street, Lancaster, Pa.

ARMSTRONG'S INDUSTRIAL INSULATION

Complete Contract Service For All Temperatures

From 300° Below Zero

To 2800° Fahrenheit



Side Entering Mixer

company's new SE series side entering mixer. The model will show how a unit can be repacked from outside the tank and also will show all the construction details. The SE type of unit has many advantages in gasoline blending and other refiner operations, it was stated.

8—Intermediate Temperature Valves

A forged steel intermediate temperature valve has been designed by Orbit Valve Company, Tulsa, "to fill a need in the intermediate temperature zone, between valves having the regular oil country rating and valves which are designed to work on high temperatures." Valve parts that might be damaged by corrosion are constructed of corrosion-resistant materials and recommended maximum working temperature is 375° F., the company says.

Featured are friction free seating, plastic stem packing, no lubrication required to effect a seal, vibration and fluxations in temperatures cause no seepage leaks, and body and bonnet are joined by fusion welding.

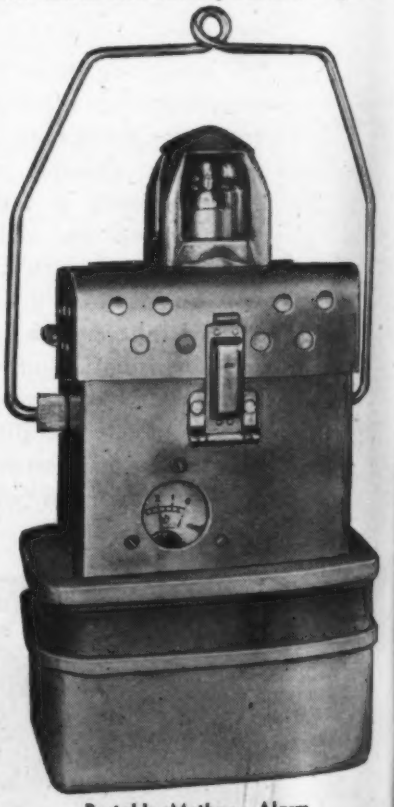
Forged Steel Intermediate Temperature Valve

Sizes: 2-inch series 150 lb., screw and flanged end. 3 and 4-inch series 150 lb. and other sizes from 2 to 4-inch in test pressures of 1000 to 10,000 lbs., ring groove and raised face flanges.

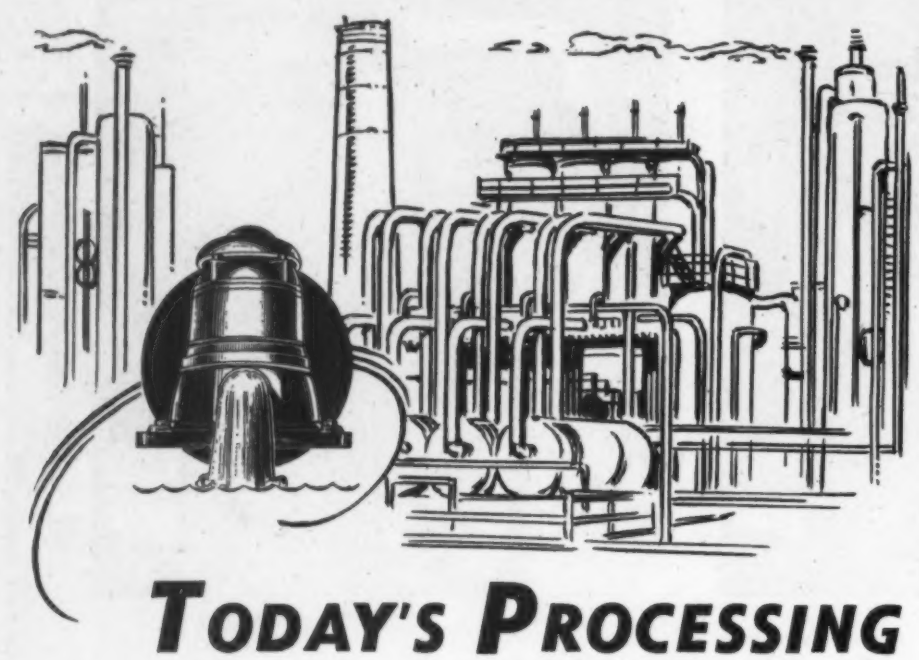
Shown at International Petroleum Exposition.

9—Portable Methane Alarm

The portable methane alarm, made by Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, Pa., is powered by a small Edison iron-alkaline battery similar to that used for operating miner's cap lamps. The alarm and battery form a single unit



Portable Methane Alarm



TODAY'S PROCESSING

DEMANDS LOW COST WATER SUPPLY

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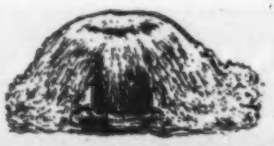
Layne well water systems are designed and built in capacities from several thousand up to many million gallons daily. Installation may be of the all weather type requiring no housing. Controls are completely automatic. Flow may be direct into the mains or to elevated tanks.

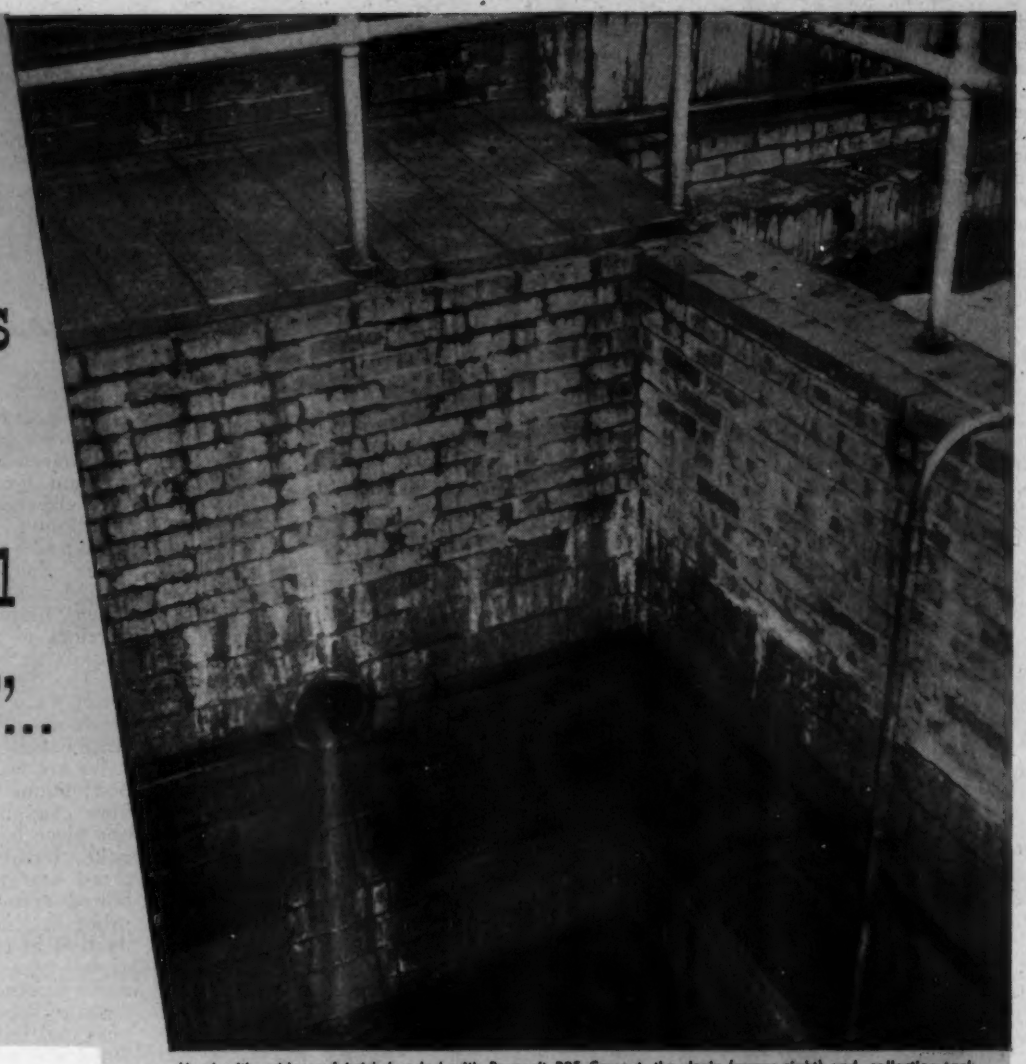
Refiners faced with many added processing operations are in need of more—and lower cost water. Old, low efficiency systems are eating heavily into profits and production is often being retarded. The way to change the situation is to install a Layne well water system and thus obtain larger quantities of water at lower cost. Layne well water systems are world famous for high efficiency, low operation cost, dependable service and long life. Once installed according to Layne standards, there is little or no upkeep cost. For literature, address Layne & Bowler, Inc., General Offices Memphis 8, Tenn.

LAYNE



WELL WATER SYSTEMS

No ulcers in this industrial "stomach"...



Lined with acid-proof brick bonded with Pennsalt PRF Cement, the drain (upper right) and collection tank handle corrosive waste liquors for neutralization and disposal, at Allegheny Ludlum Steel Corp., Dunkirk, N. Y.

It takes a hardy system to "digest" waste pickle liquors like H_2SO_4, HCl, HF, HNO_3 together with caustic, alkalis and petroleum solvents all in one gulp!

Yet that's what this industrial waste tank at Allegheny Ludlum Steel Corp., Dunkirk, N. Y., has been doing for a year and a half. Maintenance? Nil. The Pennsalt PRF Cement joints are still in excellent condition, because PRF was especially designed to withstand the attacks of these chemicals.

Pennsalt PRF Cement is a resin-type cement, quick-setting, cold-hardening, easy to use. Thin joints (1/16" to 1/8") keep costs down. It bonds well with acid-proof brick, vitrified tile, carbon and Karbate brick, asphalt, wood, and—well, why not get the *full* story? Write for folder PRF 552—Special Chemicals Division, Pennsylvania Salt Manufacturing Company, Philadelphia 7, Pa.

Pennsalt PRF Cement helps protect waste pit for Allegheny Ludlum Steel Corporation

PENN SALT

Corrosion-Resistant Cements of many types for Acids, Alkalies, Solvents

Silicate Type
- Penchlor* Acid-Proof Cement
- Penchlor* Fire-Proof Cement

Acid and Alkali Resistant Paints
- Pennpaint #1—Primer and Clear Lacquer

Resin Type
- Asplit* Cement
- Causplit* Cement
- Pennsalt PRF Cement
- Pennsalt PRFK Cement
- Pennsalt HF Cement
- Pennsalt HFK Cement

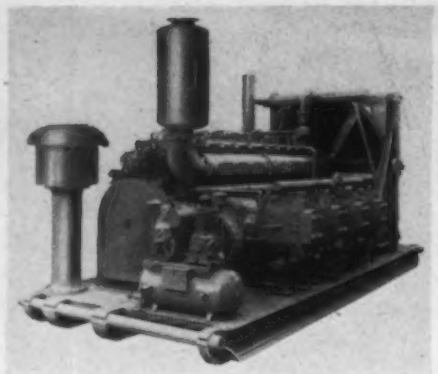
*REG. U. S. PAT. OFF.

and the total weight is less than eleven pounds. The alarm is preset to operate at a given concentration of combustible gas ranging from 0.25 to 3 percent and signals by the flashing of a lighted bulb when the surrounding atmosphere reaches that concentration. It will continue to flash until the concentration has been reduced and the detector has been reset. The alarm has been approved by the U. S. Bureau of Mines.

Shown at the International Petroleum Exposition.

10—Semi-Portable Compressor

Clark Bros. Company, Inc.'s (Olean, N. Y.) 2-cycle "Midget Angle" to be exhibited at the International Petroleum Exposition is a skid-mounted, 8-cylinder,



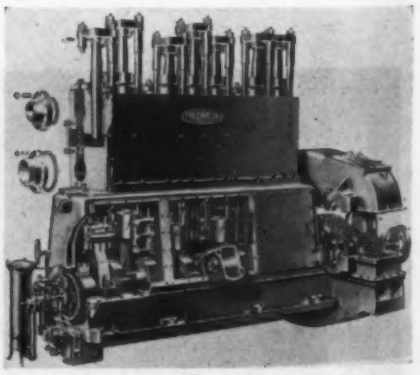
Clark "Midget Angle"

300 bhp. gas-engine-driven semi-portable compressor. Sufficiently rugged for stationary duty, is can be shipped if desired without the skid mountings for installation on permanent foundation. As a skid-mounted unit, it is light enough for portable service. The Midget Angle has an 8-inch bore and 8-inch stroke. The compressor cylinders and the scavenging pump are mounted horizontally and on opposite sides of the crankcase. Following are ranges of brake horsepowers: 2-cylinder, 75; 4-cylinder, 150; 6-cylinder, 225; and 8-cylinder, 300.

11—Edward Univalves

Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company, East Chicago, Ind., will show at the International Petroleum Exposition the newest addition to the Edward steel valve line, the forged steel Univalve, built for services to 2500 pounds at 1000° F. The 1½ and 2 inch (Fig. 2224) are said ideally suited for blow-off service and conform to the ASME boiler code. Features of the Univalve are leakproof patented seal-welded body-bonnet joint, chromium-molybdenum steel bodies and bonnets, integral one piece bonnet with renewable bronze yoke bushing, integral Stellite hard faced seat and Stellited disk, through bolted gland packing adjustment, foolproof backseat and 25 to 50 percent reduction in pressure drop. Inclined stem globe type construction retains globe valve tightness yet the streamlined flow passage approaches gate valve straightness and reduces wear producing turbulence and pressure drop to a minimum.

12—Pumps



The Aldrich Pump Company, Allentown, Pa., "in keeping with our policy of designing pumps requiring the minimum of maintenance with free accessibility to all parts," has recently developed a new line of pumps for which "the expense of carrying spare parts by the customer will be kept to a minimum

One valve stem packing that

HOLDS ITS LUBRICANT

When temperatures pass 500 F, glands need not leak or valve stems bind. Pack them with J-M Jewett No. 14, it stays pliable in high-temperature service.

J-M Jewett No. 14 is impregnated with a special lubricant that will not run out at high temperatures. Made of asbestos stiffened with copper, it is braided jacket over jacket, then formed square. This construction combines maximum sealing with minimum friction.

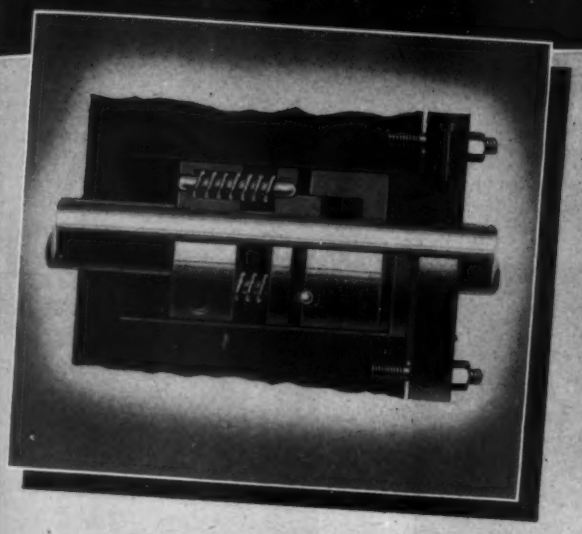
Specify Jewett No. 14 for all your valve stems in high temperature service. At your Supply House or write Johns-Manville, Box 290, New York 16, N. Y.

Johns-Manville PACKINGS & GASKETS

When writing the manufacturer of new equipment for literature or more information identify his product by name and number listed in Petroleum Refiner.

DURA SEAL

FOR MEETING THE SEALING REQUIREMENTS OF VOLATILE, CORROSIVE OR ABRASIVE FLUIDS



DURA SEAL is a mechanical sealing device designed for sealing processing equipment under conditions not satisfactorily held by conventional packings. Only Dura Seal provides all these features:

- ★ Made to fit standard stuffing boxes
- ★ Rotates with shaft-positive drive
- ★ Resists corrosion
- ★ Unaffected by abrasives
- ★ No scoring of shafts
- ★ Long uninterrupted service
- ★ Reduces fire hazard

WRITE TODAY FOR BULLETIN 174PR...illustrating and describing Dura Seal applications for better sealing.

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

The PERFECT SEAL

CHICAGO • DALLAS • DETROIT • HUNTINGTON, W. VA. • HOUSTON
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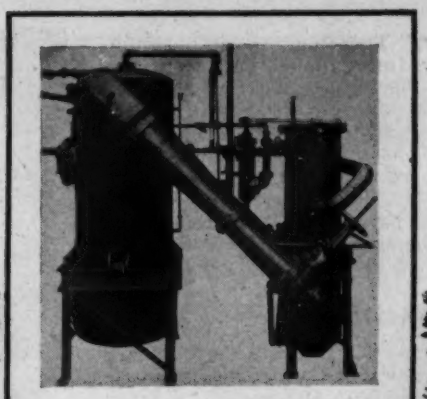
KANSAS CITY, MO. • LOS ANGELES • NEWARK



ORDER YOUR CHILLVACTOR NOW

For Chilled Water Next Summer

Every year when the warmest weather comes in July and August, we have several frantic appeals from production men in petroleum and process industries for CHILL-VACTOR equipment to maintain proper temperatures in certain solutions, in chilled water for air conditioning, for chilling various reaction vessels, and for special cooling requirements.

The Croll-Reynolds CHILL-VACTOR is one of the most dependable and efficient units available for cooling requirements in the range above 32° F. While there are a great many outstanding advantages, there are a few limitations. In recent years the most serious one seems to be the fact that these units are not made in quantity and available for immediate shipment. While they are mostly made from standard parts, each unit is custom built to a certain extent in order to provide maximum dependability and efficiency under individual operating conditions.

Under present manufacturing schedules, it requires approximately three months to design, build and ship a complete CHILL-VACTOR unit. This means that **immediate** action is advisable for those who want to be ready with new cooling capacity for the next warm weather season.

The Croll-Reynolds CHILL-VACTOR has no moving parts other than a standard chilled water circulating pump. Water is the only refrigerant. Maintenance and repair costs are therefore practically nil. Operating costs are usually less than for other types of refrigerating equipment where ample condenser water is available. Inquiries on this type of equipment will receive the careful attention of engineers with many years specialized experience in this field.

CROLL-REYNOLDS

CROLL-REYNOLDS CO.

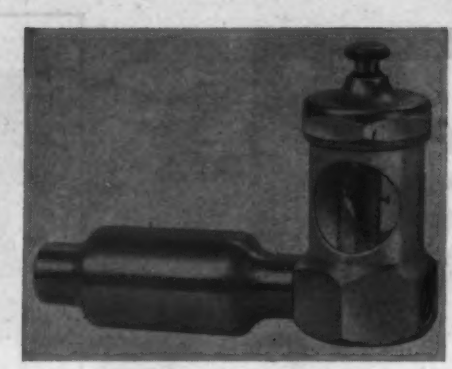
17 JOHN STREET, NEW YORK 7, N. Y.

CHILL VACTORS STEAM JET EVACTORS CONDENSING EQUIPMENT

investment." These pumps will be exhibited at the International Petroleum Exposition. The major wearing parts in this line of pumps are standard for 300-hp. triplex, 500-hp. quintuplex, the 700-hp. septuplex (shown here) and the 900-hp. nonuplex types. Other larger types are available. Therefore, with two sets of wearing parts Aldrich is able to fill pumping requirements of from 300 hp. to 2450 hp.

13—Lubricator-Filter

A "Lubri-Filter," combining a lubricator and filter, designed for compressed air lines, has been announced by Jarett Compressor & Equipment, Inc., 275 Central Avenue, Newark 4, N. J. Designed to protect air-driven equipment against "dry-running" breakdowns and impurities in the air supply, the device cleans air automatically by a permanent type, cleanable filter element which never requires replacement. Atomized oil is automatically injected into the air line in proper amounts. Oil level can be seen from any angle. Model 605 is precision-built of aluminum and brass, and provides an unrestricted air flow of ¼ inch pipe size.



Lubricator-Filter

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

14—"Servomechanisms"

In reducing a complex operation to a completely automatic process by means of Servomechanisms, %Proportioneers, Inc.% of Providence, R. I. is exhibiting for the first time at the International Petroleum Exposition continuous blending equipment for lubricating oils, gasoline, tetraethyl lead, etc. By combining functions of the Servomechanisms, many industrial processes can be greatly simplified, the company claims. In the equipment, the company has utilized for the value of the Servomechanisms to provide synchronized control for three liquids, handling two volumetrically and one gravimetrically, keeping all components in proper ratio to one another and permitting the individual selection of percentages for the respective ingredients as well as the predetermination of total production rate.

15—Pinch Valve

A new pinch valve for controlling the flow of highly abrasive and corrosive materials has been announced by Farris Engineering Corp., 484 Commercial Avenue, Palisades Park, N. J. This new product, the maker states, allows full pipe capacity with equal pressure drop, provides for simple installation and automatic alignment.

A smooth bore minimizes incrustation, permitting easy cleaning by tapping or flexing with a mallet. The valve eliminates water hammer and absorbs vibration thus preserving other equipment on the line. Maker states there are no in-

"The Choice OF THE MAJOR OIL COMPANIES"

OILCO

SAFE, QUICK, EFFICIENT VOLUME LOADING

with OILCO Dome Type Tank Truck and Tank Car Loading Assemblies

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Thoroughly tested in service under many and varied conditions by major oil companies throughout the world. Flexible! Sturdy! Efficient! Economical! OILCO EQUIPMENT is the right answer to trouble-free operation and results.

CATALOG No. 500

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OIL EQUIPMENT MANUFACTURING CO., INC.

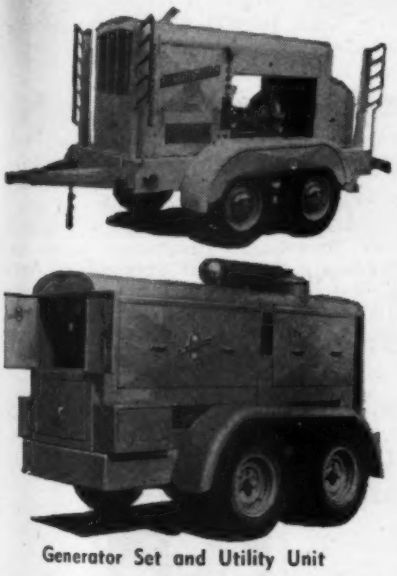
3100 Vermont Avenue, Louisville 11, Kentucky

Pinch Valve (Farris)

ternal parts to wear or cause an obstruction and "it can be placed in throttling position without undue cavitation or wire drawing, because of its streamlined design."

16—Utility Units

Stewart & Stevenson Services, Inc., of Houston, has recently developed self-contained generator sets and utility units which are mounted on either two or four-wheel trailers which can be rapidly moved to any point where electric or auxiliary power is needed. Originally



Generator Set and Utility Unit

developed for the road show business, these units are being introduced to field and construction divisions of the petroleum industry. They are powered with either GM diesel engines or Continental Red Seal gas-gasoline engines with sizes ranging from 3 kw. to 350 kw.

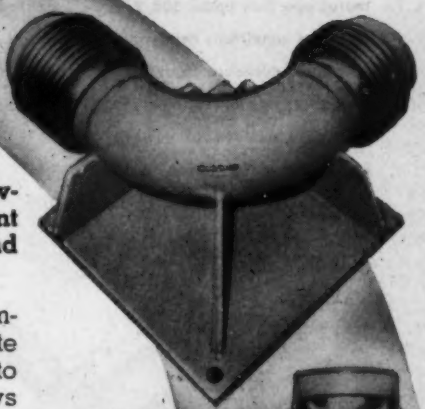
Shown at International Petroleum Exposition.

17—Electronic Receiver

Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio, is showing some of its new electronic type instruments at the International Petroleum Exposition. These include an area type fluid meter suitable for the measurement of viscous as well as free-flowing liquids; a two-pen Bailey pyrotron employing

New expansion fittings save space, piping, and installation costs

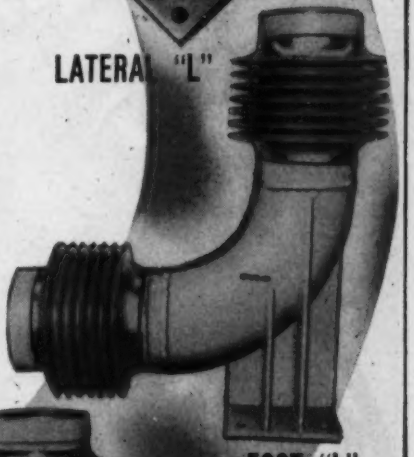
SIDE "T"



MagniLastic is first again with a new concept in simplified piping installation. Anchor base expansion joint fittings solve many plant layout problems involving limited space and movement due to changes in temperature and pressure.

As illustrated, a wide variety of combinations are possible, each complete with anchor base ready for bolting to floor, wall, or ceiling girder. Bellows are selected from standard MagniLastic catalog series to accommodate temperature, pressure and corrosive conditions. Number of diaphragms is variable to handle expansions encountered. Flanged or weld ends are optional.

LATERAL "L"

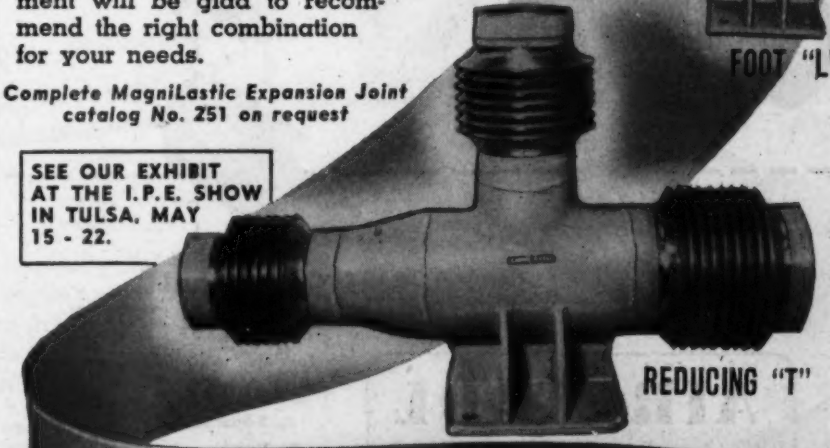


MagniLastic expansion fittings are compact, simple to install, save time, and permit economies in space, maintenance and cost of other fittings. Our engineering department will be glad to recommend the right combination for your needs.

FOOT "L"

Complete MagniLastic Expansion Joint catalog No. 251 on request

SEE OUR EXHIBIT AT THE I.P.E. SHOW IN TULSA, MAY 15 - 22.



REDUCING "T"

MAGNILASTIC

Division of COOK ELECTRIC COMPANY, Chicago 14

"THERE IS A MAGNILASTIC EXPANSION JOINT FOR EVERY PIPING NEED"

Powerful!

EFFECTIVE!

Airetool's New Geared Cleaner No. CC-325

FOR CLEANING HEAT EXCHANGER AND CONDENSER TUBES FROM ⅜" TO 2½" I.D.

Use this cleaner for thorough, fast work — even when tubes are completely closed with scale. The powerful motor operates up to 800 RPM . . . making this cleaner ideal for conditions that require low speed and extreme power. Additional features include built-in flushing system, convenient handle control valve, and a muffler that does not reduce power.

For further information, write
The Airetool Manufacturing Company,
316 S. Center Street,
Springfield, Ohio.

AIRETOOL SMALL TUBE CLEANER DRILLS

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

For use with geared or direct drive cleaners

a. B-Special Drill
b. Reamer
c. Straight Flute Drill
d. Twist Flat Drill

N. Y. OFFICE: 50 Church St., New York 7, N. Y.

There's an Airetool Tube Cleaner and Expander for every type of tubular construction!

See our display at Tulsa, Okla. during the 1948 International Petroleum Exposition.

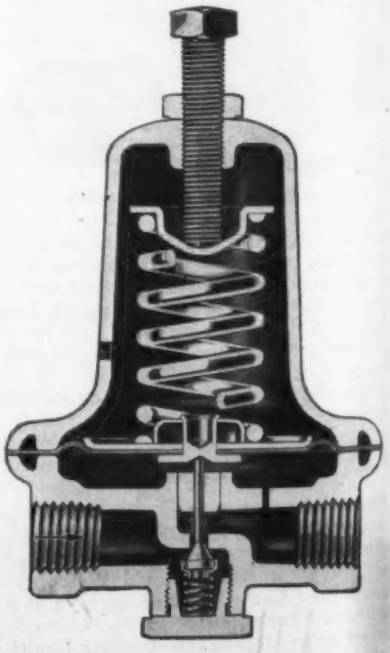
Bailey Electronic Receiver

both a thermocouple unit and a temperature sensitive resistance element; and an oxygen analyzer and recorder assembly.

Bailey one, two, three and four-pen electronic recorders, some equipped with indicating pointers and/or automatic control, may also be used for measuring pH, pressure, speed, flow, thermal conductivity, smoke density, percent oxygen and percent combustibles. The instruments are all formed from eight standardized component parts and four basic measuring circuits. With these component parts and basic measuring circuits it is possible to get more than 100,000 different measuring and controlling combinations.

18—Reducing Valve

Fisher Governor Company, Marshalltown, Iowa announces the Fisher Type 67, a self-contained pressure-reducing regulator for air or gas service applications, designed to provide "superior close pressure maintenance under exacting conditions on applications such as instrument air supply service and panel pneumatic loading for remote hand control." Specifications include:

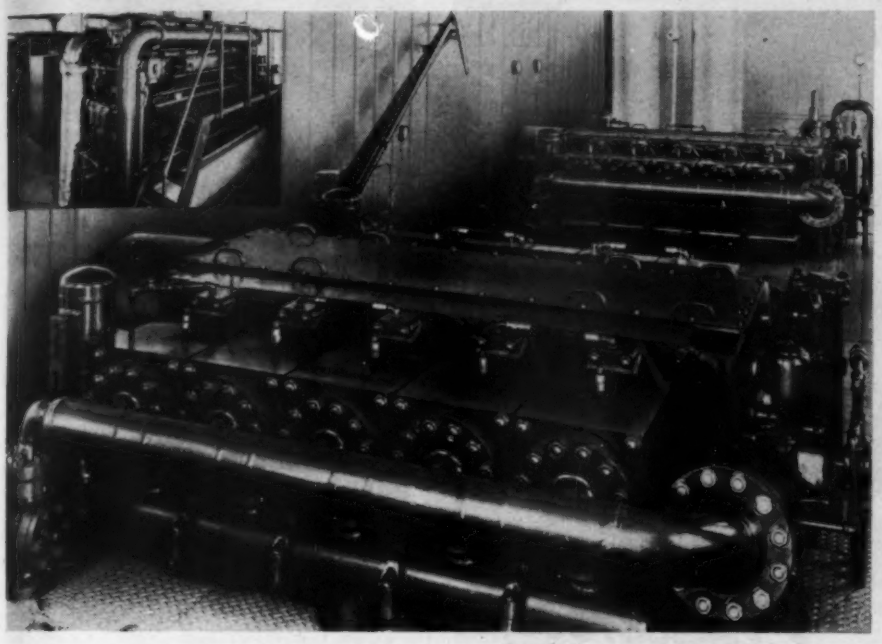


Fisher Governor Reducing Valve

¼-inch size only with capacity up to 6 cfm at 100 pounds inlet, 5 pounds reduced pressure. Reduced pressures are 3 to 20, 15 to 40 and 25 to 75 pounds.

19—Twin Line, 6-Cylinder Pump

The Cooper-Bessemer Corporation, Mount Vernon, Ohio, is showing at the International Petroleum Exposition its twin-line 6-cylinder pump which "offers great flexibility in handling liquids up to 64,000 barrels daily and pressures up to 2000 psi, a comparatively large volume output with reduction in over-all weight and space through application of high rotative speeds to opposed, short-stroke displacement plungers." The pump's normal speed of 400 rpm permits a direct-connected prime mover in many installations, eliminating gear or belt speed reduction. It can handle a great variety of liquids and pressures, has wide speed ranges; plungers are available from 3 to 6 inches in diameter and cylinder sizes are 2, 4, 6, 8, 10 and 12 cylinders. A volumetric efficiency of 95 percent minimum at 400 rpm with 1500 psi discharge pressure with still higher efficiency at lower speeds and pressures has been shown by tests with mechanical efficiency above 92 percent. It is applicable to lean oil pumping in absorption plants and hot and cold oil charging service in oil refining, etc.

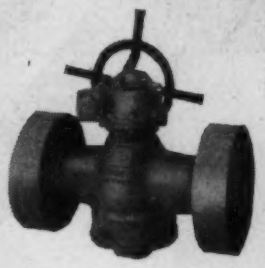


Cooper-Bessemer Twin-Line 6-Cylinder Liquid Pump

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

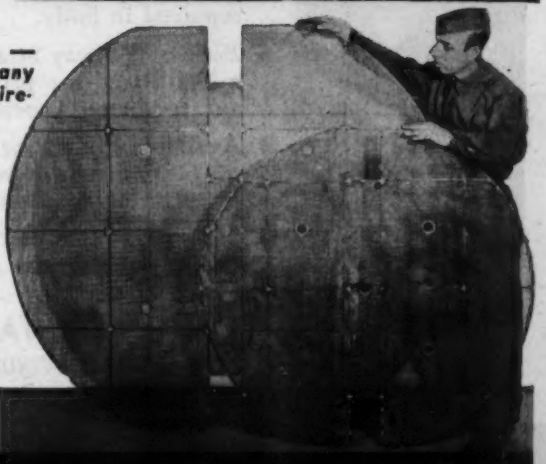
20—Nordco Steel Valve

High pressure Hyperseal Nordcoalloy steel valves conforming to API specification 6-B and 6-C and tested to 15,000 pounds for working pressures up to 10,000 pounds wog. will be shown at the International Petroleum Exposition by Nordstrom Valve Division of Rockwell Manufacturing Company, 400 North Lexington, Pittsburgh 8, Pa. These valves are primarily for service where highest pressures are developed. They are now be-



For First-Hand Answers to your FILTERING, STRAINING *and* SCREENING *Questions*

VISIT BOOTHS 30 & 31
In the KANSAS Bldg.
•
International Petroleum Exposition
TULSA, OKLAHOMA, MAY 15-22



Catalyst retainer screens — made by Multi-Metal in any metal according to requirements.

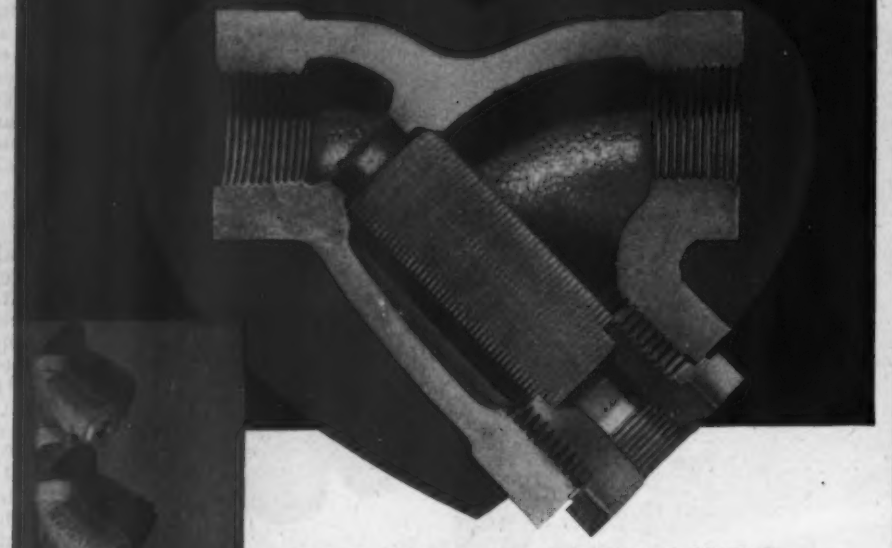
For the last 35 years, the petroleum industry has relied on Multi-Metal for a wide assortment of wire and filter cloth assemblies — from small strainers to tremendous claytower screens. Our resources and experience are ready to aid you in improving your processing operations.

Visit the Multi-Metal Booths (Nos. 30 and 31) at the Tulsa show — and learn how to save tomorrow's costs, today, with Multi-Metal fabricated wire and filter cloth assemblies.

More Than 35 Years of Service to Process Industries

Multi-Metal WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

The of the YARWAY STRAINER



MAKES PIPELINES *Lifelines*

- The heart of a strainer is its screen . . . and the screen in Yarway Strainers keeps pipelines open . . . prevents rust, scale and dirt from clogging equipment.
- *Screens* are of high-grade monel woven wire, fine enough for required straining service, yet having ample free area for passage of clean condensate, light oil or other fluids. Perforated screens if desired.
- *Screen cap* is made with straight thread, machined face and spark-plug-type gasket for attachment to body. Permits easy removal for cleaning. Insures proper alignment of screen when it is replaced in body.
- *Body* of Yarway Strainer is iron or steel, cadmium-plated for protection against corrosion and for better appearance.
- Available in six sizes, ½" to 2", for pressures to 600 lbs. Stocked and sold by 150 Mill Supply Houses. Reasonably priced.
- Hundreds of thousands in use. See your nearest dealer, or write for Bulletin S-201.

YARNALL-WARING COMPANY
128 MERMAID AVENUE PHILADELPHIA 18, PA.

YARWAY STRAINERS
"Police the Pipelines"

ing produced in 3, 3½ and 4-inch sizes and are gear operated. The flanges have ring joints and the valve has a round opening with straight-through flow. In addition Nordstrom will show Hyperseal Merchrome coated valves of 13 percent chromium for corrosive distillate service.

21—Vent Valve and Gauge

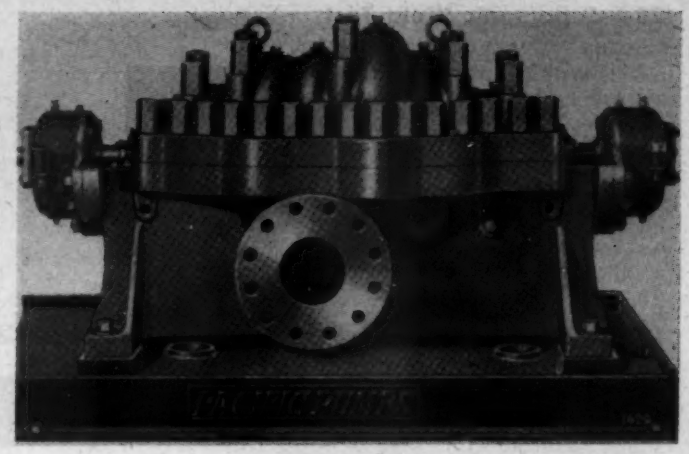
The Vapor Recovery Systems Company, Compton, Calif., will exhibit at the International Petroleum Exposition its "Varec" combination vent valve and gauge hatch, designed to protect against overpressure vacuum in bulk storage tanks. "Figure 23," pictured here is said to be low in initial cost and economical from a conservational standpoint, it being made a non-corrosive, pure aluminum with a non-sparking brass gauge hatch cover. Vent valve pallets are of hyperbolic design which together with the resulting impact area tends to eliminate chatter and minimize blow-down. Company officials claim that this is effective against daily evaporation and loss of anti-knock values, these amounting to considerable when no particular precautions are taken.

22—Refractory Panels

Latest improvements in design of its insulating refractory precast panels will be shown at the International Petroleum Exhibition by Quigley Panel Constructions, Inc., 527 Fifth Avenue, New York 17. Insulating refractory linings for practically every type of heated equipment can be constructed with Quigley precast panels. Advantages include "lower initial and maintenance costs, as well as operating and production efficiencies." Special shapes to meet specific applications are made from standard combinations of refractory materials, or of other special materials. Special designs are available for abrasive conditions.

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

23—Pipe Line Pump



Pacific Pumps Inc. of Huntington Park, Calif., a member of the Dresser Industries will introduce at the International Petroleum Exposition their new type F pipe line pump, which features a horizontal split case of small diameter and symmetrical form with integral cast diffusers in the upper and lower halves, deep packing boxes with large water jackets, ring oiled ball or sleeve bearings in water-jacketed housings. The one interstage crossover and the suction and discharge nozzles are cast integral with the lower half case. The hydraulic design features enclosed type, single suction impellers; diffusers for the efficient conversion of the kinetic energy in the liquid leaving the impellers to pressure energy; effective pressure breakdown from high to low pressure areas; guide vanes in the suction bay to equalize flow to the eye of the suction impeller and prevent cavitation and other losses resulting from cross flows.

24—Thermal System

Taylor Instrument Companies, Box 110, Rochester 1, N. Y., announces a new single capillary, organic liquid actuated Thermal System which is particularly adaptable to applications where a small bulb is required, short range intervals are desirable, the manufacturing process is sensitive to mercury and subzero temperatures are encountered. The system utilizes a single bore capillary and a single Bourdon spring with a "U"-shaped bi-metallic compensator on the spring for case temperature changes. Uniform charts are used.

25—Pipe Cutter Power Drive

The Ridge Tool Company, Elyria, Ohio, has announced a new power drive for operating hand pipe cutters, threaders and reamers, the Rigid Porta-Power drive, which weighs only 100 pounds. Cleanly housed in a modern style case, it has a 3-jaw lathe-type scroll chuck in front and a self-centering workholder in rear which turns with the pipe. Additional features include a special chuck wrench ejector, a bump-proof start and stop switch, and permanent sealed-in lubrication. The Porta-Power drive plugs into any 110 a.c. light socket; motor is reversible.

Power Drive for Hand Pipe Cutters

26—Capacity Calculator

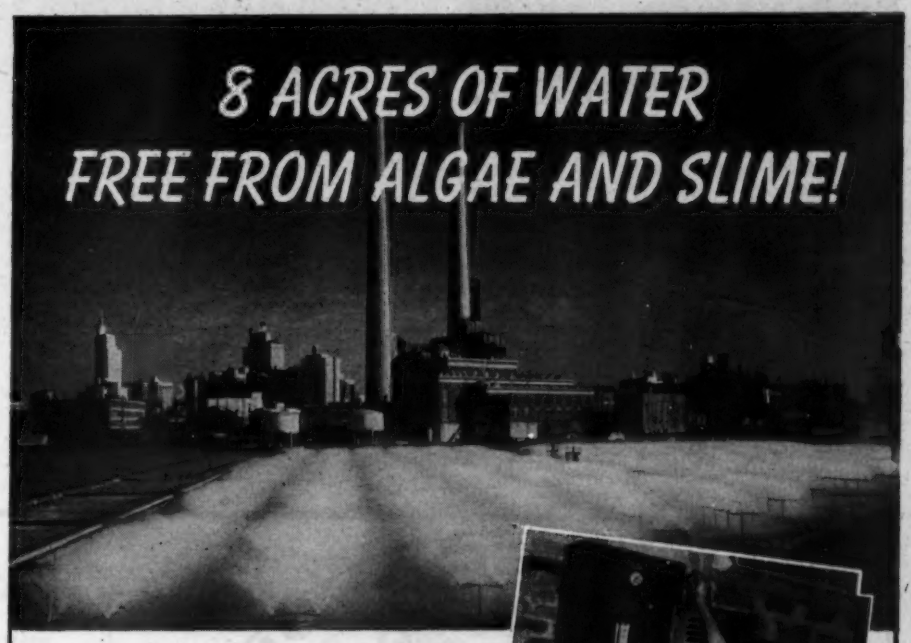
A new valve capacity calculator, made by Kieley and Mueller, Inc., North Bergen, N. J., is based on three factors: a) rate of flow through the valve, or capacity; b) static pressure and pressure drop through the valve, or resistance; c) valve size. Correction scales for steam quality and liquid and gas specific gravity are included as well as a flowing temperature scale for gases.

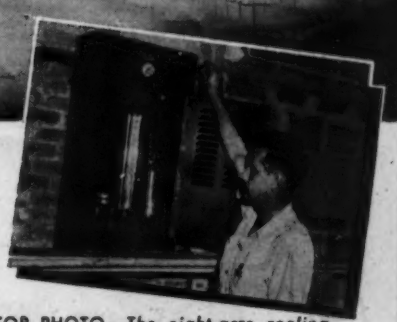
Of circular slide-rule type, the calculator is 8 inches in diameter.

27—Flexible Tubing

Ronaflex Tubing Company, Inc., Packard Building, Philadelphia 2, has announced a new buna and neoprene base flexible tubing which "stands up

8 ACRES OF WATER FREE FROM ALGAE AND SLIME!





WITH A *Paddock* HIGH-CAPACITY CHLORINATOR

TOP PHOTO—*The eight-acre cooling pond of the Dallas Power & Light Company. In center background is the huge plant which helps furnish electric power for a half million people.*

LOWER PHOTO—*A D. P. & L. plant engineer adjusts the control valve of the Paddock High-Capacity Chlorinator which serves the big cooling pond.*

Chlorinating one hundred thousand gallons of water a minute!—that's the huge task efficiently handled by a single PADDOCK High-Capacity Chlorinator at the eight-acre cooling pond of the Dallas Power & Light Co., Dallas, Texas. The PADDOCK High-Capacity Chlorinator injects up to 1,000 pounds of chlorine a day to keep cooling equipment free from destructive algae and slime. Five giant steam condensers, total capacity of 67,500 square feet, are part of the vital machinery at the Dallas power plant protected by this efficient method of chlorination.

If you have the problem of keeping down algae and slime, ask about the PADDOCK High-Capacity Chlorinator. Simple in operation. No float boxes to overflow, no float valves to wear out. Works on high-vacuum principle. Sturdy — efficient — economical. Write PADDOCK today to help estimate your chlorination needs.

Ask about SURECLOR to be used as a standby chlorinator.

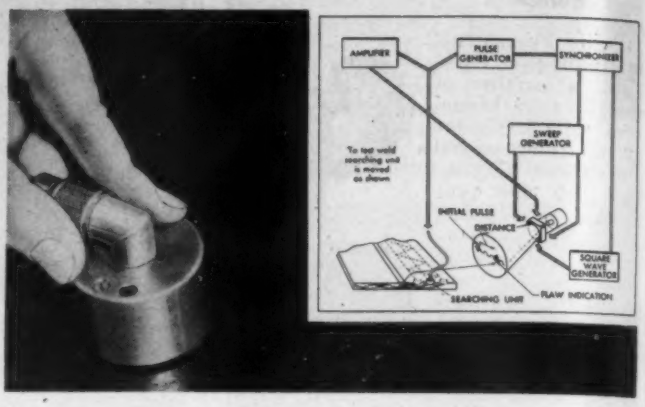
Paddock Engineering Co. of Texas

900 SOUTH ERVAY STREET DALLAS 1, TEXAS
731 M & M BUILDING HOUSTON, TEXAS

Flexible Tubing
Manufactured by the Ronaflex, Philadelphia.

under the terrific punishment of high temperatures, pressures, vibration, internal and external corrosive solvents and fumes." Rugged, light weight couplings, provided with standard Ronaflex assemblies, snap on or off in a second, yet "provide a tight positive grip that eliminates all trouble due to leaking joints." Standard sizes from ¼ to 2 inches i.d. and in a complete range of lengths up to 200 feet in the small diameter and 50 feet in the largest diameters are supplied.

28—Supersonic Weld Test

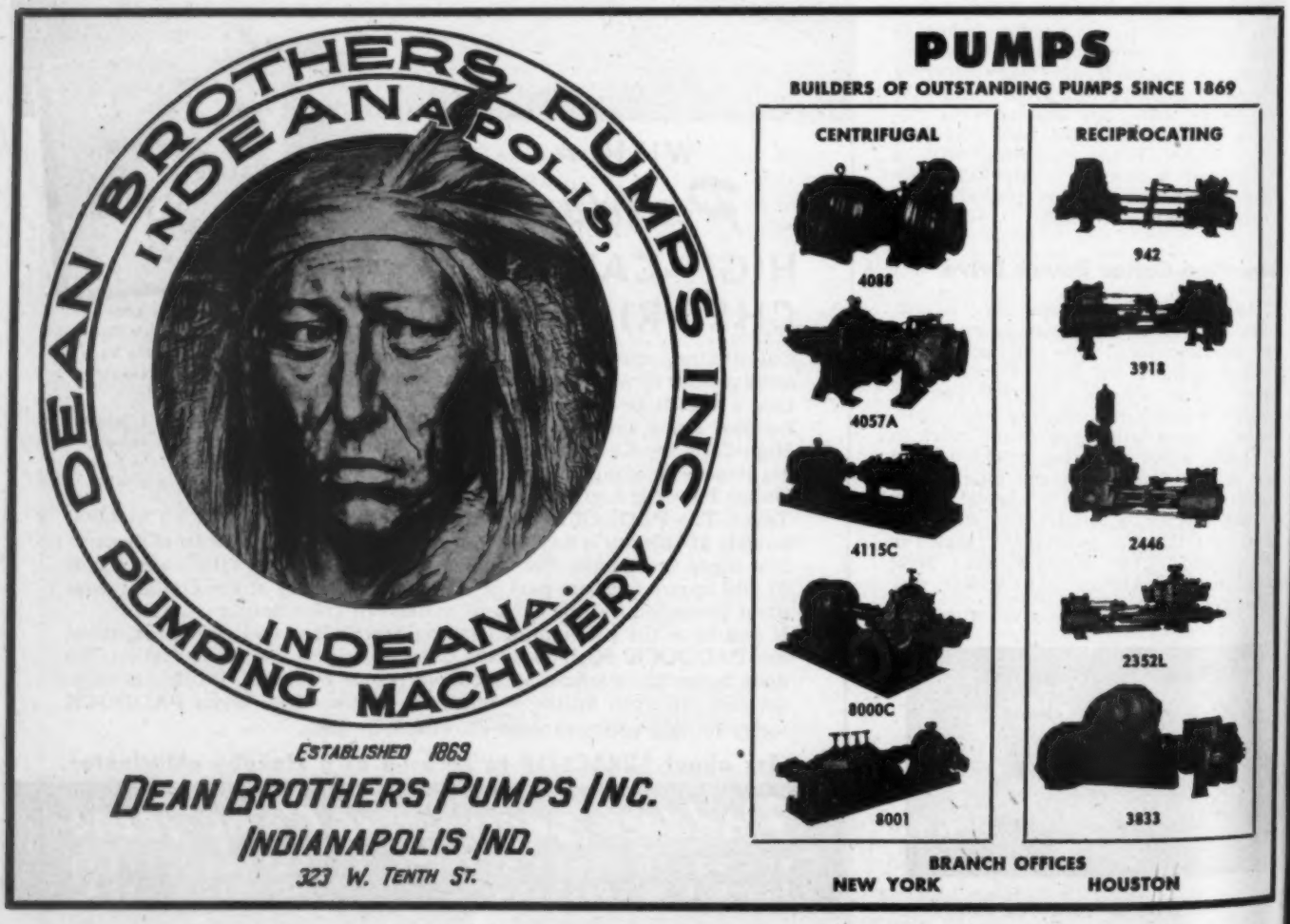


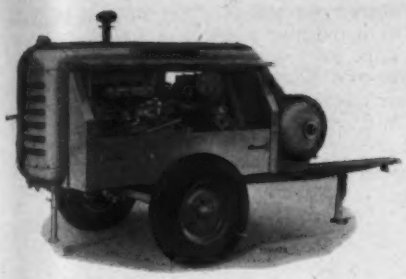
Welds in ferrous metals and light metals can be inspected for lack of bond, inclusions or voids by means of a newly developed testing technique employing high frequency sound waves generated by a supersonic Reflectoscope, manufactured by Sperry Products, Inc., 1505 Willow Avenue, Hoboken, N. J. The new development makes possible the entrance of the sound beam into the welded part at an angle. The searching unit, whose primary element is a quartz crystal, can be placed on the smooth parent metal adjacent to the weld, or even at some distance from it. The energy travels by successive reflections between the surfaces of the materials until an interface is reached. Any voids or inclusions will reflect part of the sound beam back to the searching unit where it will be amplified to provide a vertical deflection of the horizontal trace on an oscilloscope screen. A time marking system allows accurate calibration to determine the distance from the searching unit to the flaw.

With the supersonic Reflectoscope it is possible to locate smaller defects at greater depths than with x-ray or other non-destructive testing equipment. Welds in light metal plate and sheet stock can also be inspected.

29—Mobil-Air Compressors

Ingersoll-Rand Company's (Phillipsburg, N. J.) new line of Mobil-Air (portable) air compressors, designated as the KA-Series is represented by a 160-cfm unit at the show. Other sizes are 105-, 210-, 315-, and 500-cfm. New features include: Finger-tip hydraulic control of a Flex-Disc clutch which is self-adjusting and on which facings can be replaced without major disassembly; improved control of cooling system, combining adjustable shutters on the radiator and thermostatic by-pass control; design improvements resulting in lower oil consumption; improved full-range air filters; piston-type Free-Air Unloaders; and hinged, permanently attached, side covers. These machines retain the Ingersoll-Rand two-stage, air-cooled com-





I-R Mobil-Air Compressor

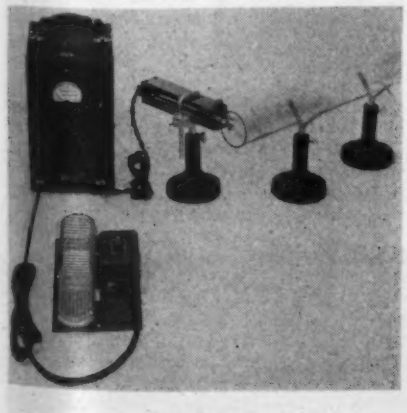
pressor, and the I-R Drill-More multi-speed regulator, all sizes have push-button electric starting, and are available with a gasoline engine, and the I-R Type H oil engine or International Harvester diesel.

30—Galvanometers

A new, completely different Type E Galvanometer just announced by Leeds & Northrup, 4934 Stenton Avenue, Philadelphia 44, has its moving system, magnet, lamp, scale and lamp transformer in a single, compact case, ready to be plugged in. Sensitivity of these instruments is ample for many potentiometer and bridge circuits which formerly required L&N galvanometers having separate reading devices. Available sensitivities are 0.5 microvolt, 0.005 and 0.0005 microampere per mm. Period is only about 3 seconds. This instrument also has, in effect, an added low sensitivity which is a great help in initial stages of measurement. Its scale has 50 1-mm divisions on either side of zero. Deflection is linear within 1 percent.

31—Glass Cutter

Eberbach & Son Company, Ann Arbor, Mich., has developed the "even heat glass tubing cutter" with which glass tubing up to 7½ inches can be cut in any position as a separate piece or as an integral part of apparatus already set up. Adjustable supports are provided but the unit can be used in any position when detached from its support. A foot switch is available as an accessory for controlling power when the operator needs both hands free. The electrical shock hazard is said to be eliminated.

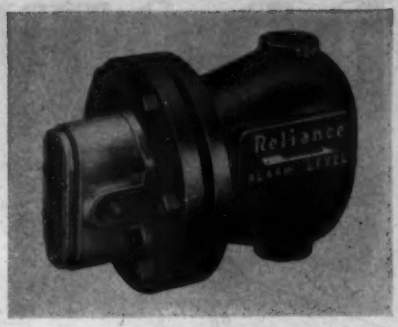


Glass Cutter

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

32—Liquid Level Alarm

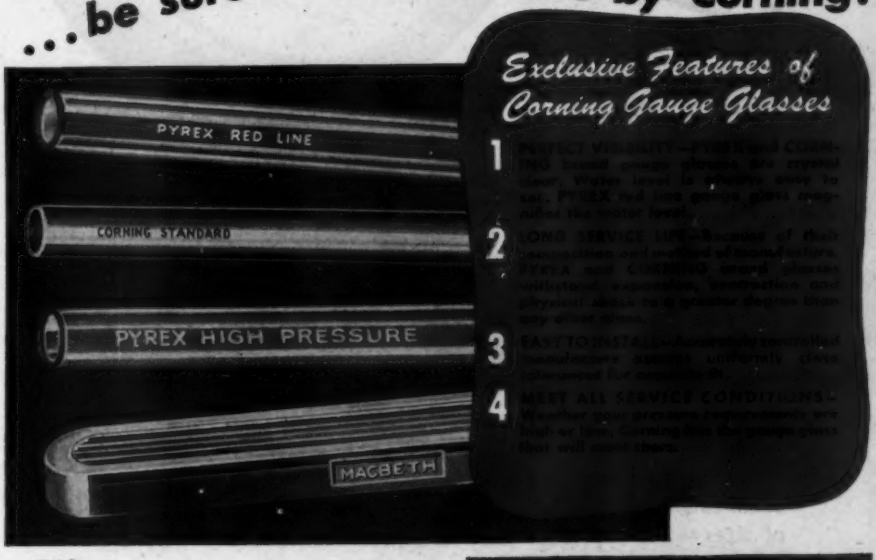
A new device to set off warning signals when liquid levels in small boilers or tanks reach predetermined low or high levels has been announced by The Reliance Gauge Column Company, 5902 Carnegie Avenue, Cleveland, Ohio. This



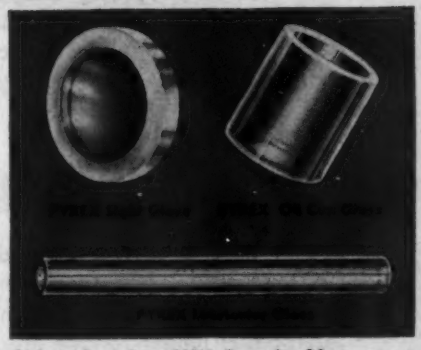
Liquid Level Alarm

"Levalarm" can be used on pressures up to 250 pounds. An electric switch is op-

BE SURE YOU HAVE EXTRA GAUGE GLASSES
...be sure they are made by Corning!



When you need gauge glasses, you need them quick. Low water in your boiler, for example, could cause damage costing real money. But a broken gauge glass wouldn't reveal the danger. There isn't any economy in being without spares. There just isn't any economy in being without Corning products. They provide the most dependable service at the lowest possible cost.



Other Corning Mill Supply Glassware

PYREX brand sight glasses; PYREX and CORNING brand Lubricator and Oil Cup Glasses.

Sold only through Leading Mill Supply, Plumbing and Heating Wholesalers, Hardware Wholesalers, etc.

CORNING means research in GLASS

T.M. REG. PYREX U.S.PAT.OFF.

CORNING GLASS WORKS, CORNING, N.Y.
SALES OFFICES: NEW YORK, CHICAGO, SAN FRANCISCO
PYREX GAUGE GLASSES
BRAND

TECHNICAL PRODUCTS DIVISION: GAUGE GLASSES • GLASS PIPE • LIGHTING WARE • LABORATORY GLASSWARE • OPTICAL GLASS • ALLOYS AND MOLYBDENUM

PROTECTION

by ACCURACY

"Acragage"

For Precision *plus* Economy

For pressures and vacuums . . . with ranges from water inches up to 30,000 P. S. I. . . . there's an ACRAGAGE scientifically designed to give you dependable precision on steam, oil, gas, chemicals, water, or brine. ACRAGAGE comes in a wide variety of sizes — 4½", 6", 8½", or 10", with wall, stem, or true flush mountings. ACRAGAGE cuts down your operating expense . . . protects you against costly errors and inaccuracies.

20% to 30% Longer *Bourdon* Tubes

Bourdon tubes in the ACRAGAGE are 20% to 30% longer than average . . . resulting in the following advantages: less strain per unit length on the spring; increased durability; longer fatigue life; heavier wall thickness for added safety; greater tip-travel — providing sustained accuracies to within one-half of one percent!

Remember ACRAGAGE — a quality product made by skilled craftsmen from materials which meet rigid standards, including Army and Navy specifications.

WRITE for folder on SPECIAL TYPE 316 PETROLEUM GAGE

CLAPP INSTRUMENT CO.

Acragage

WEBSTER, MASS.

erated through the agency of a permanent magnet when a monel float rises or falls in a separate float chamber. The switch can be wired for a normally open or normally closed circuit—is dust, vapor and explosion-proof.

33—Fogfoam Nozzle

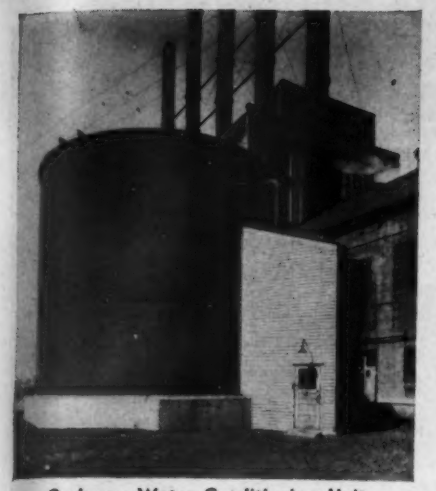
Type FFF "FogFOAM" nozzle, announced by Rockwood Sprinkler Company, 38 Harlow Street, Worcester 5, Mass., is a new development for extinguishing flammable liquid fires. It is equipped with a screen that discharges a wide protective pattern of "FogFOAM" that can be applied directly to such fires. The screen can be removed and replaced with a foam shaper to allow the nozzle to discharge a long range stream of solid foam. The nozzle is available for services on 1½, 2½, and 3½-inch hose. "Far greater extinguishing action than possible with old style equipment" is claimed for the nozzle.

34—Acid Filled Solder

Solder Division of Alpha Metals, Inc., 363 Hudson Avenue, Brooklyn 1, N. Y., has announced a new development in acid core solders Alpha Tri-Core "Leakpruf" acid-filled solder. Heretofore Tri-Core has been available only with the rosin-filled flux. The development of this hard acid flux is the first innovation in the field of acid core solder since 1929, the company claims. Advantages include its ability to solder stainless steel, monel, nickel and other metals hitherto not usually solderable with a core solder; the synthetic acid used is considerably more active as a flux than the usual zinc chloride, yet only half as corrosive; and a definite soldering sequence which is automatically developed by three cores of flux and which practically eliminates "cold solder joints."

35—Water Conditioning

Bulletin 4425, "Cochrane Rapid Reactors," distributed by Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, describes a cold process softener that combines the basic elements of equipment for mixing, floc formation, settling, and thickening in a



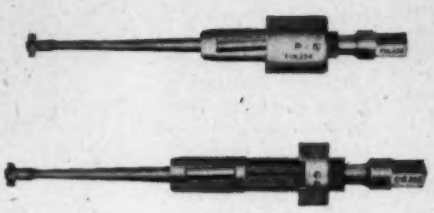
Cochrane Water Conditioning Unit

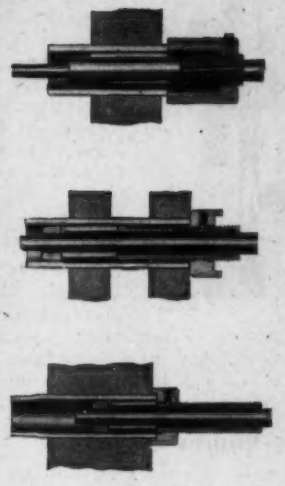
single reaction vessel. The new equipment is designed for the conditioning of process cooling water and boiler feed. Chemical reagents may be introduced for coagulation of turbidity alone, for partial softening with coincident turbidity reduction, or for complete softening and turbidity reduction.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

Wiedeke

TUBE EXPANDERS FOR DEPENDABLE
. . . ECONOMICAL SERVICE





WIEDEKE Adjustable Tube Expanders
Designed especially for rolling small tubes in Condensers, Heat Exchangers and similar units.
Style No. 254 is adaptable for rolling tubes to a depth of 2"
Style No. 269 is adaptable for rolling tubes in heavier or multiple tube sheets.
Leading users everywhere know there is a Wiedeke Tube Expander for every application.
For complete details, see your local dealer or write us today

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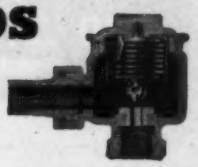
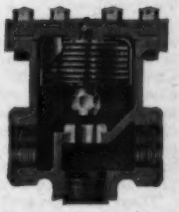
A List of Nationally-known REPEAT Clients will be mailed you on request

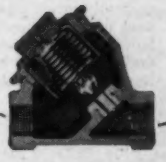
WIGTON-ABBOTT CORPORATION
PLAINFIELD, NEW JERSEY
Telephone: Plainfield 6-8100

Nicholson Simplicity Enables You to

STOP Adjusting Steam Traps







Nicholson traps require no adjustment or change of valve and seat from 0 to 225 lbs. This feature proves an exceptional trouble-saver in plants with many and varied trap applications. With these other 5 features, it accounts for the increasing standardization on Nicholson traps: 2 to 6 times average drainage capacity; operate on lowest temperature differential; no freeze-ups, air binding, nor waterlogging.

5 Types for Every Purpose:

power, heat, process; size ¼" to 2"; steam press. to 225 lbs. Also weight and piston-operated traps for steam, air, gasoline; press. to 1500 lbs. Expansion steam traps for press. to 225 lbs.

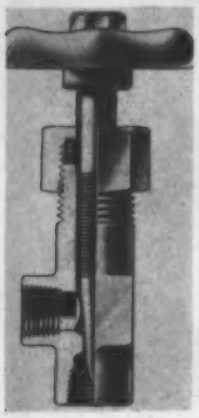
W. H. NICHOLSON & CO.

207 Oregon St., Wilkes-Barre, Pa.
Valves ★ Traps ★ Steam Specialties

***BULLETIN 1047** is a valuable reference on advanced drainage methods. Or see Sweet's.*

36—Needle Valve

The Bulldog needle valve is built with a stainless steel stem, having the longest practical taper possible in a valve of its length, according to Carpenter Manufacturing Corporation, 9523 Detroit Avenue, Cleveland 2. In combination with this extremely slim needle, to effect the ultimate in delicate flow-control, a real micrometer thread is machined on the stem. This thread allows the valve to be opened or closed in tenths of a thousandth, thus effecting absolute accuracy of control. The bodies are machined from solid bars, eliminating possibilities of porosity leaks. The threads in the body are a class 3 fit and are inspected to Aircraft Standards.

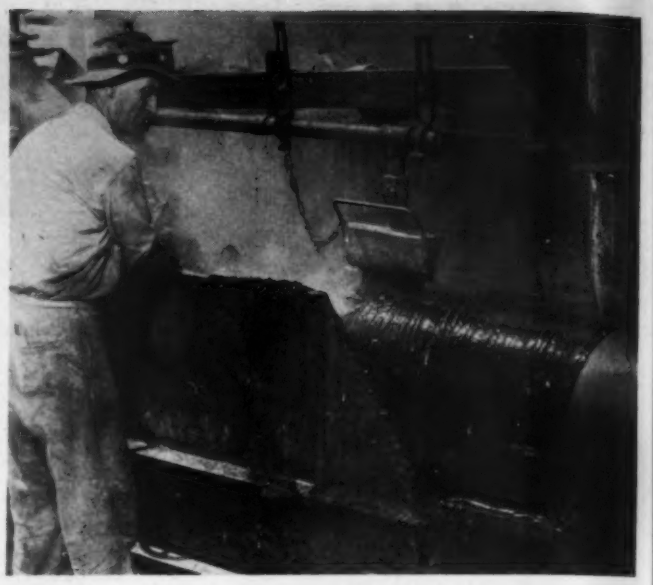


37—Radius Extension

A new radius extension bar has been created by Scientific Research Company, Box 263, 1618 N. Vancouver Ave., Portland 12, Oregon for the Flash Circle burner as an accessory. This special extension bar is made of rigid cold-rolled steel, and the adaptor is permanently fixed to the bar by induction silver soldering. An aluminum set screw with cut threads is set diagonally on the adaptor. The special extension bar is quickly readied to flame cut circles up to 60 inches in diameter.

38—Pipe Coating

Duratex, now available to general industry, according to National Petroleum Sales, Inc., 315 West 9th Street, Los Angeles, is a "new protective coating with exceptional resistance to electrolysis and corrosion." Duratex also is said to have outstanding shock impact resistance, great ductility, and unusual stability. It is said to be easy to apply and will not settle out or "coke-up" after repeated reheating or retempering and does not require agitation in the heating kettle.



Pipe Coating Machine

39—Chrome-Base Concrete

A high-strength, chrome-base refractory concrete, known as Kromecast, which is able to withstand temperatures as high as 3100° F., has been developed by The Babcock & Wilcox Company, 85 Liberty Street, New York 6. The new product is said to make available for the first time an easily installed concrete combining the refractory and slag-resisting properties of chrome-base materials with the ability to support loads at high temperatures. Kromecast can be poured into place as easily as ordinary concrete or applied by plastering or with a cement gun. It "can be installed in a fraction of the time required for plastics and, because of its strength at elevated temperatures, can be used to construct vertical walls and roof arches in many types of furnaces that formerly had to be made of less resistant materials."

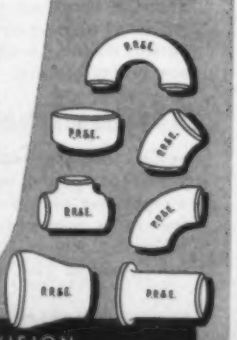
For use in furnaces where temperature and spalling conditions are not as severe as those requiring the use of Kromecast, The Babcock & Wilcox Company announced a second new product, Hydrochrome, a chrome-base concrete which

SAVE INSTALLATION and Production Time on Stainless Piping

with P. P. & E. Stainless STEEL WELDING FITTINGS

P. P. & E. stainless steel welding fittings reduce the cost of installing a stainless piping system—because any system can be constructed with them simply by straight cutting of tubes to desired lengths and plain butt-welding. Complicated "angle" cutting and fitting is eliminated; fewer welds are needed; and faster, uniformly sound welds are assured. A clean, lastingly efficient, trouble-free system is the result since pockets and sharp corners that cause erosion, product accumulation, and pressure drop are eliminated.

These fittings are available in Stainless Types 304, 316, and 347 to match piping and tubing of various wall thicknesses in sizes from ¼" through 12". Send for Catalog S-309 which gives complete specifications and list prices of the world's most complete line of stainless welding fittings.



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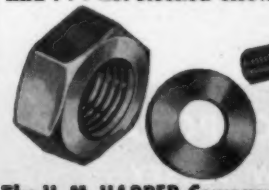
PITTSBURGH PIPING and EQUIPMENT COMPANY
10 43rd Street · Pittsburgh, Penna.
World's Largest Manufacturer of Stainless Steel Welding Fittings

10 TO 1!
FOR
HARPER FASTENINGS

Ten reasons for using nonferrous and stainless fastenings by Harper . . . only one for common steel. Harper fastenings resist rust, resist corrosion, many are non-magnetic, others are non-sparking, all are usable again and again, are attractive in appearance, easy to clean, have high strength, give long service life and show lower ultimate cost. The only advantage for common steel is lower first cost.

5000 STOCK ITEMS . . . maintained in Chicago and New York. Large quantities of each. Many are rare and hard to find . . . not stocked elsewhere. Write for complete catalog.



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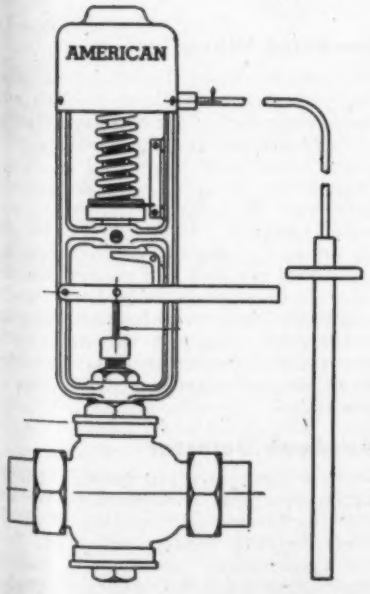
has a temperature use limit of 2800° F. and is recommended for the great majority of water-cooled boiler furnaces and for metal processing furnaces with moderate operating temperatures.

BJ "Bilt-on" Pump

40—"Bilt-on" Pumps

Byron Jackson Company, Los Angeles, will exhibit its line of "Bilt-on" pumps at the International Petroleum Exposition. These pumps are designed with interchangeability of basic parts. With eight cases, eight motors, nine impellers and a stock of small parts it is possible to assemble a Bilt-on pump that will handle capacities from 10 to 600 gpm. at heads up to 340 feet. There are 322 pump combinations available with the plan. The units are particularly easy to assemble since the Bilt-on has a single shaft common to both pump and motor.

41—Temperature Regulator



Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has announced an action temperature limiting regulator for use on processing machinery where a positive shut-off is required when the critical temperature has been reached. The accuracy of actuation is obtained by carefully ground and fitted stainless steel

than 9 lives!

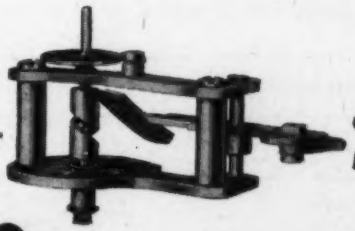
When ordinary pressure gages are used on corrosive sour oil or gas, they last only 5 to 6 weeks. That's what one company* found. Then they tried Helicoid gages with K-Monel tubes.

After 55 weeks, they were removed for inspection. There were no signs of corrosion. The gages tested accurate and were put back in service.

This is a typical case proving how money is saved by using Helicoid Gages. There are countless other examples.

For better gage value for any kind of service, insist on Helicoid—the gage of enduring accuracy.

*Name on request



Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

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Here's why Petroleum Refiner is wanted by so many refinery men—

THOROUGH coverage of current technical and economic thought in the field of petroleum refining, natural gasoline and petrochemical manufacturing.

PRACTICAL articles written by outstanding authorities of the industry.

"SHORT CUTS" published under the heading of "How To Do It" which bring you practical suggestions which have already made and saved money for other companies.

DETAILED data on new processes and improvements on old ones.

INFORMATION on practical as well as theoretical phases of process plant design and operation.

A REVIEW of technical literature on refining, natural gasoline and petrochemical manufacturing making quickly available the source of additional data on a subject of particular interest.

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Specialized for the oil refining industry including Petrochemical engineering, petroleum synthetics and natural gasoline

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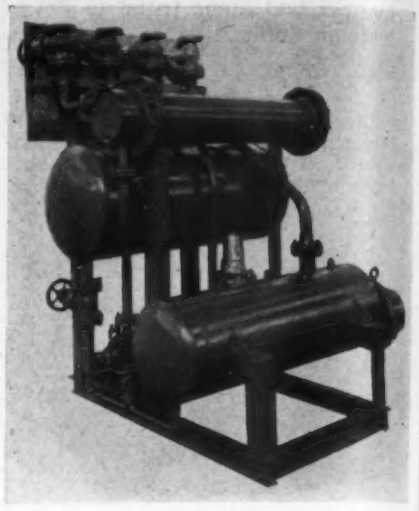
Engaged in: ☐ **Refining** ☐ **Natural Gasoline** ☐ _____ (Other)

parts. Manual resetting is achieved by simply raising the "cocking" lever. It is made in three sizes; ½, ¾ and 1-inch and for temperatures from 20 to 345° F.



Cooling System

42—Dowtherm Heating-Cooling

Blaw-Knox Company, Blawnox, Pa., started production of the first portable units of its self-contained Dowtherm heating and cooling system. The system consists of one 100,000-Btu. per hour Blaw-Knox electro-vapor generator; one 100-gallon Dowtherm surge tank; one 50-square foot Dowtherm cooler; one cooling pump for circulation of the liquid Dowtherm; one complete charge of Dowtherm "A" heat transfer fluid; and the instrumentation and framework complete with control panel.

During the heating cycle, Dowtherm fluid is vaporized by the action of a 30 kw. electric immersion heater with explosion resistant terminal cover. Design working pressure for the vapor generator is 60 psi.

43—Print Wheel

An improved skip-numeral print wheel which when used with strip chart electronic recorders "permits symmetrical and well-defined multiple measurement records" has been developed by Brown Instrument division of Minneapolis-Honeywell Regulator Company, 4498 Wayne Avenue, Philadelphia 44. The skip-numeral print wheel overcomes a crossing of records and superposition of numerals of any one record, utilizes the same basic system of plus and numerical identification, staggers the numeral locations for different records permitting use of slower chart speeds, it was explained.

44—Leak Detector

A new leak detection device for industrial applications is announced by Vacuum-Electronic Engineering Co., 316 Thirty-Seventh Street, Brooklyn, N. Y. The Veeco mass spectrometer leak detector, manufactured under license of the University of Minnesota, is applicable wherever a vacuum, fixed pressure or special atmosphere must be maintained in equipment for extended periods of time, or for insuring leak-protection of many manufactured items. It is designed for simplicity, ease and continuity of operation and by non-technical personnel. Ask for LD-81.

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

44-A—Working Pressures

Tube Turns, Inc., Louisville 1, Ky., has issued an enlarged edition of "Allowable Working Pressures," which designers, fabricators and users of industrial piping systems will find an important and time-saving reference source. Given are allowable working pressures for Tube-Turn welding fittings in five classes of piping.

45—Ammonia

"Ammonia in the Petroleum Industry," published by The Mathieson Chemical Corp., 60 East 42nd Street, New York 17, explains in detail the uses of anhydrous ammonia in the petroleum industry. Installations of typical equipment and processes are described and the chemical and physical properties of ammonia and the general precautions to be observed in its safe handling and application are discussed.

46—Asbestos Textiles

"Johns-Manville Asbestos Textiles" is the title of brochure SP-7A just published by Johns-Manville Corporation, Box 290, New York 16. Shown are asbestos mining operations, carding and spinning machines and the various asbestos textile products, including reproductions of ten popular styles of asbestos cloth. Descriptions of asbestos roving, lap, yarn, cloth, clothing, safety curtains, tubing, cord, wick, rope, tape and oil burner wicking also are included as are tables showing specifications.

47—Safety Orders

E. D. Bullard Company, 275 Eighth Street, San Francisco 3, has prepared a digest of petroleum safety orders of the Division of Industrial Safety, state of California. Serving as a convenient reference, the digest specifies proper approved equipment to fulfill each requirement.

48—Centrifugal Pump

Ampco Metal, Inc., Milwaukee 4, Wis., has announced a centrifugal pump, constructed of corrosion resistant aluminum bronze and suited for handling salt water or other corrosive and abrasive applications. The new pump is a single stage, single suction, closed impeller model with capacities up to 240 gpm and heads up to 170 feet. Sizes are 1½ x 1¼ inches, 2 x 1½ inches and 2½ x 2 inches. Liquid passages streamlined for high efficiency and quiet operation and with bearing thrusts reduced by hydraulic balance, the pumps come in close coupled and pedestal types. Shown at International Petroleum Exposition.

49—Safety Equipment

Wheelco Instrument Co., 847 W. Harrison St., Chicago 7, manufacturers of the "Flame-otrol," a combustion safeguard for gas or oil-fired furnaces and other heating equipment, has announced two new improvements: A "safe start relay," mounted on the chassis, which prevents operation in the event that any unsafe condition exists during start-up period. A "blue sensitive" photo cell for the "Flame-eye," sensing unit which is responsive only to blue spectral rays, characteristic of oil flames. This eliminates detrimental effects of red rays reflected from furnace walls or other extraneous sources. Ask for Bulletin Fl-1.

50—Weldments

Black, Sivalls & Bryson, Inc., 720 Delaware, Kansas City 6, Mo., has issued a folder "Weldments" describing and picturing various types of welded steel plate structures in which BS&B has had experience and is equipped to do.

51—Containers, Flasks

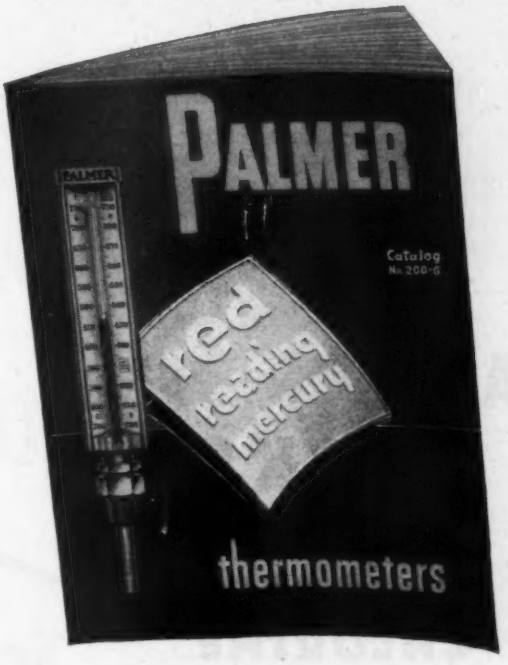
Hofman Laboratories, Inc., 212-218 Wright Street, Newark 5, N. J., have issued a bulletin, "Containers and Flasks for Liquefied Gases." These containers, of copper and other metals, with double walls separated by a nearly perfect vacuum, are described by photos, charts and text.

52—Swivel Joints

Chiksan Company, Brea, Calif., has issued a new catalog covering Chiksan ball-bearing swivel joints and fabricated products. Included is a color code for identification of each type of swivel joint according to its pressure capacity. Cutaway views are used to show the design and construction of basic types

YOU'VE BEEN WAITING FOR IT

HERE IT IS . . .



IT'S NEW

IT'S FREE

Forty pages designed for ready reference! The new Palmer catalog is really a handy thermometer guide. Here are all the details and specifications you need to select the correct thermometer for every refining and process need. Send for your copy today.

For further help on all thermometer questions, there is a Palmer representative near you.

We'll See You at the Tulsa Show
Booths 60 and 61
Scien. & Tech. Bldg.

Mfrs. of Industrial, Laboratory Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, Ohio

Canadian Plant:
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Outstanding Palmer Features
—New Extruded Brass Case with chrome finish
—Easy-to-see "Red-Reading-Mercury"
—Guaranteed permanent accuracy

PALMER THERMOMETERS INC.

and packing units and weights and dimensions also are shown together with complete instructions for servicing and lubrication.

53—Pipe Strainers

Bulletin 184, decribing ½" to 2" cast semi-steel Y-type pipe strainers for steam, gas, air, water and oil lines has been issued by Armstrong Machine Works, Three Rivers, Mich. Detailed information is given on strainers with either perforated brass screens or fine mesh woven stainless steel screens.

54—Forged Steel Valves

The Ohio Injector Company, Wadsworth, Ohio, has issued a new catalog describing its full line of forged steel valves. Design and construction, materials, ratings and markings of the various types of valves are described in detail.

55—Steam and Water Mixer

Sarco Company, Inc., Empire State Building, New York 1, has issued catalog 900 describing a new steam and water mixer to provide hot water at isolated points. Cut-away photographs show operation, installation, and construction and capacity and dimension tables are included.

56—Couplings

Bulletin 48-6 on Baldwin-Rex roller chain flexible couplings has been released by the Baldwin-Duckworth Division of Chain Belt Company, Springfield 2, Mass. Design, application, selection and prices are given and to clarify intricate design and application features, cutaway, "explosion" photos and simple drawings are used.

57—New D/P Cell

The Foxboro D/P Cell, new development in metering equipment, is recommended by The Foxboro Company, Foxboro, Mass., for the solution of difficult problems in the measurement of flow or liquid level. It weighs less than 20 pounds, is easily held in a man's hand, and is convenient to install. All parts exposed to the measured fluid are of stainless steel, eliminating most corrosion troubles and, in many cases, the need for seals. The D/P Cell is available in ranges from 100 - 800 ins. water. Range change is a simple operation. The D/P Cell employs the force-balance principle. Essentially, the measured differential pressure is converted by a diaphragm and torque tube into exactly proportional air pressure, which is transmitted to the receiving instrument and there shown in terms of flow, liquid level or differential pressure. The receiver or receivers may be indicators, recorders or controllers, and transmission may be pneumatic or by ordinary cable to a Foxboro Dynalog electronic recorder. Shown at the International Petroleum Exposition. Ask for bulletin 420.

58—Self-Adjusting Wrench

E-Zee Tool Manufacturing Company, 136 Liberty Street, New York 6, has announced a new automatic self-adjusting and self-locking wrench "with a perfect ratchet action." It is available in 6 and 8-inch sizes. The jaws are made from chrome vanadium drop forged steel.

59—Polishing Supplies

Availability of Bulletin No. 208 on Metallographic polishing supplies featuring the new metallographic polishing compound "C-RO," is announced by Burrell Technical Supply Co., 1942 Fifth Avenue, Pittsburgh 19. "C-RO" eliminates the common practice of etching and rebuffing in many cases, and quickly prepares previously difficult-to-polish materials, the bulletin states.

60—Tube Fitting

Flodar Corporation, 331 Frankfort Avenue, Cleveland, Ohio, has a new catalog which describes in detail the role of tube fittings in the sealing of higher fluid pressures. Portrayed are the engineering difficulties caused by tube fitting failures and design, construction and performance of Flodar fittings on high fluid pressure installations.

61—Silica Gel Dehydrators

The Engineering Division of The Davison Chemical Corporation, Baltimore 3, Md., has issued Bulletin No. 401 describing silica gel dehydrators for compressed air and gases. Equipment for dehydrating any given volume of gas under any specified condition to any desired moisture content is described by photographs, charts and text. A "dehydrator nomograph for saturated gases under pressure" also is offered.

LENAPE
MANWAY NECKS
FOR
HOODED
CHLORINE
TANKS

Typical of the versatility of Lenape Press Forged products is this 18" manway of silicon killed steel with special 37" O.D. flange. In addition to standard bolting, an outer circle of holes has been tapped to attach the hood or dome.

Lenape seamless necks, nozzles, and other pressure vessel fittings are produced in a complete range of sizes to code or private specifications in carbon steel, alloy steels, stainless, and other alloys.

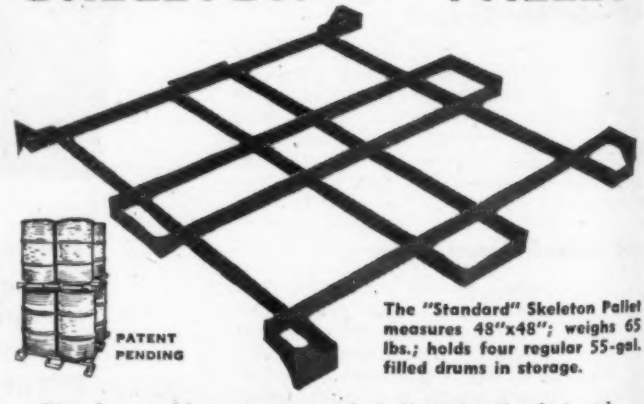
Send blue prints and/or specifications for recommendation and prices. Our engineering department will be glad to discuss particular problems without obligation.

Quotations will be given our immediate attention — Bulletin 4-61 and current price schedule M-47 will be sent upon request.

LENAPE HYDRAULIC PRESSING AND FORGING CO.

LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 106 WEST CHESTER, PA.

Announcing
SKELETON all-steel PALLET



PATENT PENDING

The "Standard" Skeleton Pallet measures 48"x48"; weighs 65 lbs.; holds four regular 55-gal. filled drums in storage.

Here is something new—a practical all-steel pallet designed with semi-open framework for easier loading and unloading by hand or fork truck. Can be used for filled drum storage, outdoors and indoors.

The Skeleton Pallet combines light weight, durability, low first cost and low up-keep. It is the ideal unit for palletizing and depalletizing drums, barrels and rectangular types of firm containers. Skeleton Pallets are available in several sizes; can be built to meet your special requirements if desired.

SKELETON -PALLET- Engineered by LAPHAM

Write for literature

PACIFIC CHAIN & MANUFACTURING COMPANY
4200 N. W. Yeon Avenue • Portland 10, Oregon

When writing the manufacturer of new equipment for literature or more information identify his product by name and number listed in Petroleum Refiner.

62—Pressure Reducing Valves

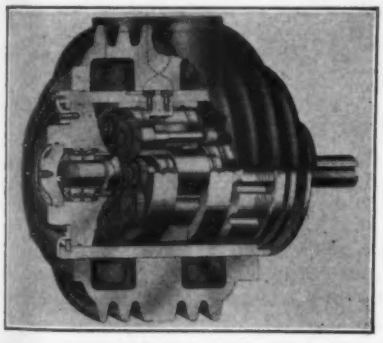
Northern Equipment Company, 1945 Grove Drive, Erie, Pa., announce Bulletin 477 on Copes pressure reducing valves. Described are several types of pressure reducing valves designed for precision control of reduced steam water, or other fluid pressures.

63—Stop Watches

The Herman H. Sticht Company, Inc. 27 Park Place, New York 7, has issued Bulletin 576 describing imported Swiss stop watches of Minerva make. These feature the "non-breakable, patented, coil-spring mechanism." A great variety of watches, is described.

64—Unit Substations

Multi-circuit unit substations and their economy, safety and adaptability features are covered in Bulletin 11B6935 released by Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis. Construction details are given of three transformer types — oil-filled, "Chlorextol" liquid-filled and dry-type. Also described are construction highlights of the load ratio equipment and the metal-clad switchgear.



65—Rotocycle Pumps

This new pump, of the fixed volume, double acting type with all operating parts held in hydraulic and dynamic balance, will be shown at the International Petroleum Exposition by the Hydraulics Division of Rockwell Manufacturing Company, Pittsburgh, Pa. Working mechanism consists of a symmetrical rotor assembly, suspended within the pump body on a horizontal drive shaft that freely turns in anti-friction bearing mounts. The rotor carries four half-moon shaped impeller vanes equally spaced on its outer circumference. These vanes are geared together in 2-to-1 ratio. As the rotor is turned by applied torque, the position of these vanes varies with respect to the sidewalls of the circular pumping chamber; always however so that each pair of diametrically opposed vanes forms two closed compartments per rotating cycle. The liquid being pumped in conjunction with closely controlled clearances provides capillary sealing between the high and low pressure areas in the working chamber. This pump is particularly suited to pumping non-lubricating liquids.

THE ZALLEA Stainless Steel Expansion Joint shown above is one of many installed in the outdoor steam distribution line of a large eastern industrial plant which has a production capacity of over $100,000 per day.

The failure of one of these joints would halt production and result in costly delays. But these Zallea Expansion Joints, installed years ago, are still doing a "bang-up" job today of "protecting" daily production by absorbing movement due to contraction and expansion of the steam line.

Long life, dependability and trouble-free performance are built into Zallea Expansion Joints to make them last, even in the severest service. There's no packing to deteriorate . . . no maintenance required. Be *sure* of your expansion joints . . . specify Zallea.

Zallea Corrugated Expansion Joints are made in non-equalizing, self-equalizing and duo-equalizing types, depending upon operating conditions . . . of copper, stainless steels and corrosion-resistant alloys . . . up to 72" diameter for a very wide range of temperatures and pressures. Send NOW for complete information contained in the new Zallea Catalog 47. ZALLEA BROTHERS, 890 Locust St., Wilmington 99, Del.

Zallea
EXPANSION JOINTS

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

... YES, you would think we were magicians. Our magic is composed of our engineering know-how *plus* our personnel initiative *plus* our own shops which fabricate standard and special equipment. This formula makes it possible for us to effect short schedules for our clients.

PROCESS DESIGN
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MECHANICAL ENGINEERING
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115 FULTON STREET
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About EQUIPMENT SERVICE SUPPLIERS

Fluor Sets Up Mid-Continent Gas-Gasoline Division

A new division of The Fluor Corporation, Ltd., the Mid-Continent Gas-Gasoline Division, was set up May 1 with offices in the M & M Building, Houston, with Ernest Moncrief, manager in charge.

Moncrief

This division is to handle engineering, drafting, purchasing and accounting, together with construction, using Fluor's regular field personnel, on gas-gasoline, cycling and dehydration plants in the region east of the Rocky Mountains.

Along with Moncrief, Fluor personnel is being transferred to Houston as follows: J. L. Tathwell, engineering department; William F. Chapin, process department; Tom H. Hanks, accounting department; and C. E. Richardson, purchasing department.

General American Transport Names Lester Selig Chairman

Lester Selig, who started work with the General American Transportation Corporation 33 years ago, on April 27, was selected chairman of the board. Max Epstein, who has been chairman, was elected chairman of the executive committee.

John P. McFadden of Rockville Center, Long Island, was named a director and vice president to succeed Bennett Epstein, retired. McFadden has been with General American for 33 years. Howard C. Westfall, eastern manager for the company's tank, storage terminal division, was elected assistant secretary.

Growing diversification of interests of the company was pointed out by President Sam Laud in his report. Originally an operator of tank cars, the company is now a manufacturer of many different types of freight cars, a lessor and operator of even more types, operator of terminals and oil storage plants, molder and manufacturer of plastics for both industry and general consumers, and manufacturer of motor coaches and many specialized types of machinery.

Air Reduction Changes

Air Reduction Sales Company's former apparatus sales department and the former arc welding sales department have been merged into one department to be known as the equipment sales department. H. F. Henriques is general sales manager, Dale D. Spoor becomes manager of the equipment sales department, Ira B. Yates becomes manager of arc welding and supplies sales and J. F. Carroll becomes manager of apparatus sales.

Reed Sent to Houston

George Reed, a metallurgical engineer with The Timken Roller Bearing Company has been appointed sales engineer of the company's Steel and Tube Division, with headquarters in Houston. He came to the Timken Company in 1941, following his graduation from the University of Michigan with a master of science degree in engineering.

Construction of this new tube mill in Decatur, Ala., was begun last year and is planned for completion this year by Wolverine Tube Division of Calumet & Hecla Consolidated Copper Company, Detroit. Construction includes a mill building, an engineering building, an electrolytic building, a boiler house, laboratory, and a gate house with a total area of 368,300 square feet. The mill will manufacture seamless non-ferrous tube and introduce the operation of a new electro-deposition unit for producing tube.

Republic Supply Company Sold; A. B. Judd Is New President

Judd

Collins

Catlow

Lollar

Republic Supply Company has been sold by Republic Steel Corporation, Cleveland, Ohio, the parent firm. Purchasers are former Governor Robert S. Kerr, D. A. McGee and associates of Oklahoma City. The latter interest owns Murray Tool & Supply Company which has stores in Oklahoma City, Elmore City, and in Pawhuska. A manufacturing plant is maintained at Pawhuska. These three Murray stores will be added to Republic's 51 sales and service points.

A. B. Judd, for many years, vice president and general manager of Republic Supply Company, becomes president. Don Collins, Oklahoma City, president of Murray Tool will be executive vice president and H. B. Catlow vice president and manager of sales. Collins will move to Houston, the company's headquarters. John H. Lollar, Jr., Republic secretary and treasurer, continues in the same capacity.

Founded in 1910, Republic Supply today operates sales offices and stores in Arkansas, Colorado, Illinois, Kansas, Louisiana, Mississippi, New Mexico, Oklahoma, and Texas.

With the exception now of the specialties produced by Murray Tool & Supply, Republic manufactures no products of its own but serves as a supply outlet for the products of more than 200 leading manufacturers. The company's new central warehouse and store in Houston, will be the general supply depot.

Republic Supply's new store in Lake Charles, La., was opened April 24. Acting as head hosts for the celebration were M. H. Suggs, store manager; R. R. Goforth, office manager; C. R. Smith, refinery and industrial representative; J. C. Spillar, oil field representative; and M. E. Cassidy, floorman.

Mathieson Changes Name

The Mathieson Alkali Works, New York, announced March 30th that it had changed its name to Mathieson Chemical Corporation.

From its beginning in 1892, the company has grown to its present size with plants at Saltville, Va., at Niagara Falls, N. Y., and Lake Charles, La., and with a production capacity of more than 600,000 tons of basic chemicals annually. Distribution facilities include warehouses located in 16 cities.

Mathieson has opened a new southern sales area with headquarters at New Orleans. Vernon Woodside will be in charge of the New Orleans sales district. Roland F. Boehm succeeds W. S. Hammond, recently deceased, as district sales manager at Houston.

Iddles Is Named President Of Babcock & Wilcox Company

A. G. Pratt, president of The Babcock & Wilcox Company, on April 8 was elected chairman of the board, and Alfred Iddles, previously a vice president, was named president and chief executive officer of the company. Pratt has been with the company for 45 years, during seven of which he served as vice President and 24 years as President. Iddles joined the company in 1937 and became a vice president in 1945.

W. T. McCullough, Jr., who was in charge of stationary boiler sales and formerly sales manager of the Chicago office was elected a vice president, and W. G. Dryden, formerly treasurer, secretary and treasurer. C. W. Middleton, vice President and secretary, has withdrawn from full-time active service but will continue as a director.

Factory Training Course Is Announced by M. M. & M.

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., have adopted a program of factory training for the executives and salesmen of their distributors whereby these men receive first hand knowledge of the design, construction, and application details, not available to them other than through the experience they receive at the point of manufacture.

Several classes are scheduled to be conducted during 1948 in which many of their distributors serving the petroleum industry have been invited to participate. The enthusiastic response of MM&M distributors is reflected in the three classes conducted thus far this year and the May and June classes now allocated, E. M. Dunlap, director of sales, said.

Brown Opens Shreveport Office with Fair in Charge

Effective April 1, D. J. Fair was transferred from the Dallas office and opened a district office for the Brown Instruments Division of Minneapolis-Honeywell Regulator Company in Shreveport, La., at 330 Garrett Building, 940 Margaret Place. Fair has been in Dallas as industrial sales engineer for 18 months.

Fair

Additional personnel has been added to the Brown Instrument's Division in the Dallas office. Charles F. Woods will continue to assist Fair in the territory.

Peerless

Fire Pumps

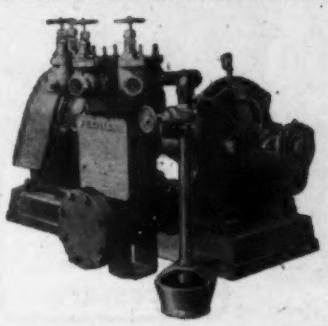
Underwriters' Approved
Horizontal & Vertical Types

For a Permanent and Reliable Water Supply For Fire Protection . . .

What This Approval Means To You:

In specifying Peerless Fire Pumps you're assured of meeting requirements of both your local fire code and the firm which writes your insurance. A Peerless installation may also mean a worthwhile reduction in your fire insurance rates.

HORIZONTAL CENTRIFUGAL TYPE*

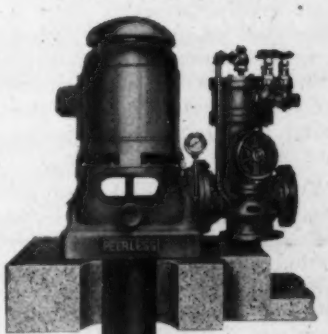


Built for instant, reliable operation. Fully automatic, minimum maintenance required. Made for motor, engine, or steam turbine drives.

Capacities: 500 to 2000 g.p.m.; heads: 40 to 150 lbs.

**Formerly Dayton-Dowd*

VERTICAL TURBINE TYPE



Especially suited to pumping water supply from wells, tanks, lakes, rivers or sumps. Compact design. Choice of oil or water lubrication. Approved types of drive include electric, right angle gear, or steam turbine. Capacities: 500 to 2000 g. p. m.; heads: 240 to 285 ft. or higher.

fmc PEERLESS PUMPS

Request Descriptive Bulletins

PEERLESS PUMP DIVISION

Food Machinery Corporation

Factories: Los Angeles 31, Calif.; Quincy, Ill.; Indianapolis, Ind. *District Offices:* New York 5, 37 Wall Street; Chicago 40, 4554 No. Broadway; Atlanta Office: Rutland Bldg., Decatur, Ga.; Dallas 1, Texas; Fresno, Calif.; Los Angeles 31, Calif.

Are YOU Working in the DARK . . . With HIGH PRESSURES?

The New JERGUSON Series 50 HIGH PRESSURE GAGE

The SAFE Gage for engineers who want to KNOW WHAT GOES ON

TESTED to 20,000 Pounds Pressure

Pat. Pending

THE New Jerguson Series 50 High Pressure Transparent Gage takes your high-pressure work *safely* out of the dark and lets you see what's going on.

Built with a new design that gives greater strength than any other gage of its type . . . tested up to 20,000 pounds. Made in sizes to fit your specific need; chamber and cover made of bar steel stock; O-ring gaskets to minimize pressure on glass.

You can see liquid level accurately; you can observe color and density of liquids. Don't "play around in the dark" with high pressures. See and know what goes on. Insist on the safety of a Jerguson dependable high pressure gage.

Write for details . . . or put your problem up to Jerguson engineers. We'll work with you.

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Representatives in Major Cities
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Russell Heads New Texas Division for Hammond

Terry Russell has been appointed sales manager of the Texas Division for Hammond Iron Works. He will headquarter at the company's recently opened offices at 531 Esperson Building, Houston, covering the states of Texas, Louisiana and Oklahoma.

Russell

Russell, a graduate of the University of Texas in mechanical engineering, has been in the oil industry equipment sales business for the past 12 years, working in both California and Mid-Continent areas. He is a member of the Nomads, having made two trips to South America.

Hammond Iron Works recently opened a manufacturing plant at Port Neches, Texas, to make tankage and plate fabrication.

Thompson Joins Frontier

Courtenay M. Thompson, formerly southwestern sales manager for Southern Alkali Corporation, has joined Frontier Chemical Company, electrochemical manufacturers of Midland and Denver City, Texas, as sales manager. Thompson, a graduate of Harvard, has been active in the alkali industry in the southwest since 1940, except during the war. He will be located at Frontier's general office, Midland Tower, Midland, Texas.

Foster Snell Associates

Foster D. Snell, Inc., has announced an association with Drs. Bredt and Van de Kasteele of N. V. Technisch Chemisch Adviesbureau of Eindhoven, Netherlands. Snell's other overseas connections include association with MacTaggart and Evans Ltd. of London, England and O. A. Mendelsohn and Co. of Melbourne, Australia.

Eggelhof Building

Eggelhof Engineers, representatives for Clark Manufacturing Company, Fulton Sylphon, and Kieley & Mueller, Inc., and others have announced letting of contract for their new office and warehouse at 1912 Hussion Street, Houston. Plans call for completion of the new headquarters by June, 1948.

Redding Marks Anniversary

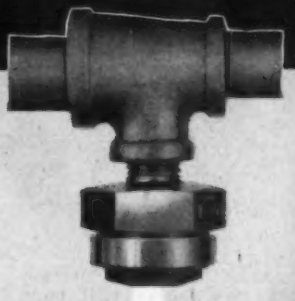
Charles S. Redding last month observed his 40th anniversary with Leeds & Northrup Company, of which firm he has been president since 1939. He was feted by 90 of his associates at a dinner at the Manufacturers Country Club, Oreland.

Redding first entered the employ of Leeds & Northrup as a draftsman in 1901, soon after his graduation from Northeast Manual Training School.

To South America

Ed T. Landgraff, manager New York office of Chiksan Export Company, is making a four-months trip through South America covering all the important oil-producing centers.

SH-H-H! OIL MAN SLEEPING!



Let him sleep . . .

Blaw-Knox Fog Nozzles protect his plant from fire. Non-clogging and instantly available, they are fire's worst enemies.

This highly perfected spray head is especially well fitted for refinery and tank farm installations. It delivers a "fog-plus spray"—a cloud of fine blanketing fog plus a driving spray that reaches the base of the fire, cooling and quenching.

Listed by Underwriters' Laboratories, Inc., and approved by Factory Mutual Laboratories.

Ask for Bulletin No. 2207

ALSO— Blaw-Knox offers Standard Wet and Dry Pipe Systems, as well as Thermostatically Controlled and Supervised Deluge Systems.

BLAW-KNOX
SPRINKLER DIVISION
of Blaw-Knox Construction Company
829 Beaver Ave., N. S.,
Pittsburgh 12, Pa.
Offices in Principal Cities

Aluminum Company of America is using more than 6.25 million pounds of aluminum in the construction of its nearly-completed Davenport, Iowa, sheet and plate rolling mill. The plant is basically an all-aluminum project, with the exception of 25,000 tons of structural steel framework which is painted with more than three carloads of aluminum paint. The works is being equipped to turn out the widest aluminum sheet in the world.

"Aluminum has been utilized only where it possesses definite advantages over other materials in weight, cost, physical properties, ease of erection, maintenance, or one of several other factors," company officials said.

Morton-Gregory Corporation Acquires Nelson Stud Welding

Purchase of the manufacturing assets and patent interests of Nelson Stud Welding Corporation of Lorain, Ohio, and its associated companies, developers and leaders in the stud welding field, by the recently-formed Morton-Gregory Corporation of Michigan was announced last month. Henry J. Morton of Detroit is president and George E. Gregory, Toledo, vice president and general manager of the new firm.

Acquisition of the stud welding business by Morton-Gregory, which has executive and sales offices in the Manhattan Building, Toledo, broadens its activities in the electrical specialty field to embrace construction, railroad, automotive, shipbuilding and other metal-using industries

All of the Nelson manufacturing and engineering activities will be centralized at the Lorain plant, which will be known as the Nelson Stud Welding Division of Morton-Gregory Corporation. Nelson's present staff of field engineers and its 18 engineering offices will be continued as part of this division.

The Morton Research Laboratories will continue operations in Detroit as a division of Morton-Gregory.

Plomb Builds Warehouse

Plomb Tool Company, Los Angeles, has added a warehouse at its Jamestown, N. Y. plant for stocking the complete line. The new warehouse, completed early in March, is a modern two-story structure equipped with many new facilities.

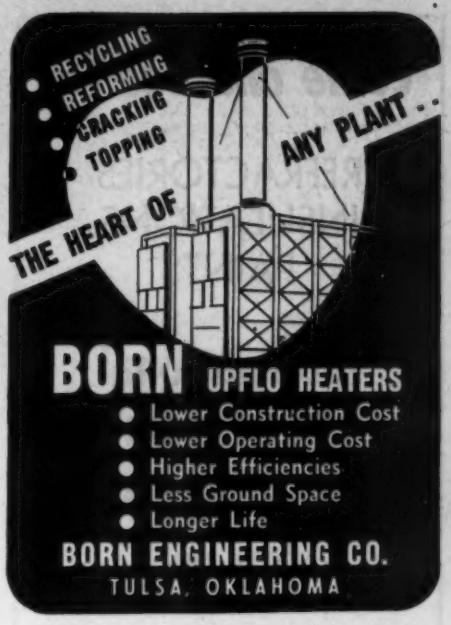
Kennedy Elects New Officers, Charles Kennedy President

Kennedy Valve Manufacturing Company of Elmira, N. Y., has announced election of Charles F. Kennedy as president.

Kennedy

Kennedy, with the company since he was graduated from the University of Michigan in 1937, was promoted from assistant works manager to vice president and works manager in June, 1947. He is a grandson of the late Daniel Kennedy, who founded the business in 1877.

Matthew E. Kennedy, who has been president of the company since 1928, was elected chairman of the board of directors and will also retain his position as treasurer.



RESULTS COUNT!

A gasoline stabilizer charge pump rod in Warren Petroleum Company's plant No. 20 at Fairbanks, Texas, was metallized in 1942.

SINCE THAT DATE, PACKING HAS BEEN REPLACED ONLY ONCE.
THE ROD IS IN EXCELLENT CONDITION.
NO SCORING — NO LEAKAGE.

Before metallizing, the rod scored which caused leakage and ultimate rod and packing replacement.

Write for complete information on how metallizing can reduce your maintenance costs.

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QUICK TURBINE REPAIRS

If you need dependable Turbine repairs *in a hurry*, call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

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REFRACTORIES
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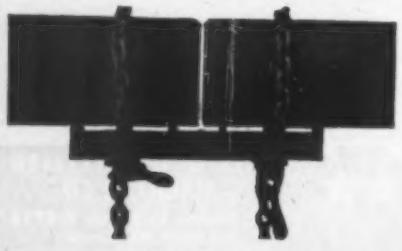
International Petroleum Exposition

BOOTH NO. 1
TULSA, OKLAHOMA
MAY 15 TO 22, 1948

QUIGLEY COMPANY, Inc.
527 FIFTH AVENUE
NEW YORK 17, N. Y.



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Faster... Easier... Truer
WITH
JEWEL PIPE CLAMPS

They align pipe perfectly and hold it secure for tacking. On in a minute — off in ten seconds. Two sizes, ½ to 8 in. — 8 to 16 in. Rigid construction resists strain, heat, and abuse.

Other Jewel Clamps for Ells, long and short turn — for Flanges — for Headers. Also Pipe Marker, eliminates patterns for holes and saddles.

So simple — so easy to use — Jewel Tools are proving big time-savers in refinery piping fabrication and erection.

Write Today for Details and Prices

JEWEL Manufacturing Company
1841 University Ave.
ST. PAUL 4, MINNESOTA

Barnes Named Sales Head of National Radiator Company

Barnes

John C. Barnes has been named vice president for sales of National Radiator Company, Johnstown, Penn. Barnes was a former sales manager of the Company's Washington and Philadelphia offices, and has been associated with the firm since 1940.

Yarnall-Waring Announces Sales Organization Changes

Yarnall-Waring Company, Philadelphia last month announced appointments in its sales department as follows:

R. S. Pollard, formerly of Pyle-National Company, has been made sales manager of the steam trap division; Leland C. Campbell has been appointed Southwestern representative, working from the Dallas sales office; Howard R. Wunker, sales representative in the company's new Cincinnati office and J. Frank Long, sales representative in the company's new St. Louis office.

Fisher Governor Company Names Sales Representative in Virginia

Fisher Governor Company, Marshalltown, Iowa, has announced appointment of W. H. Kidd & Company as the Fisher district sales representative for Virginia, with headquarters office at 309 Cowardin Avenue, Richmond.

W. H. (Cap) Kidd, who heads the new Fisher sales office, has been associated with the Foxboro Company for 16 years and at the time of his recent resignation to open his sales engineering office, was manager of the chemical controls division for Foxboro.

Sales Policy Changes Announced For Meriam's Western Division

The Meriam Instrument Company, Cleveland, Ohio, has announced a change in sales policy throughout its Western Division.

G. M. Cooke at 270 Fremont Street, San Francisco 5, and Charles Meriam at 6311 North Figueroa Street, Los Angeles 42, will be exclusive representatives for the company. Arrangements with the company's former jobbers have been terminated and stock will be carried by the representatives.

Ray to Economy Pumps

Economy Pumps, Inc., Hamilton, Ohio, has announced the appointment of H. R. Ray as special engineering consultant. Ray will specialize in the chemical, refining and process industries.

He comes to Economy Pumps from Mainistee, Mich. where for the past two years he has operated his own consulting engineering firm. Previously he had been associated with Dean Brothers, Indianapolis, for ten years and with Manistee Iron Works at Manistee.

York Enlarging Plant

Otto H. York Company Inc., is enlarging its plant facilities, the new plant being located at 364 Glenwood Avenue, East Orange, N. J. The company is engaged in engineering and manufacturing mist and entrainment separators, high efficiency multi-stage liquid-extraction equipment, tower packing, etc.

Liquid Conditioning Adds to Its Plant at Linden, N. J.

Liquid Conditioning Corporation is building an addition to its plant at Linden, N. J., providing facilities for its engineering department and also permitting expansion of its chemical laboratories, research division and other departments.

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Littlefield Appointed

L. H. Littlefield has been appointed general sales manager for Wolverine Tube Division of Calumet & Hecla Consolidated Copper Company.

Littlefield

Littlefield, formerly affiliated with the Holtzer-Cabot Division of the First Industrial Corporation, will headquarter in the general offices of Wolverine Tube Division in Detroit. He assumes his new duties on May 1.

W. H. Maxwell, director of sales for Wolverine Tube, made the announcement.

Hercules Showing Research Work to College Students

Hercules Powder Company, Wilmington, Del., has inaugurated a series of tours of several of its plants and laboratories for student chemists, chemical engineers and their professors. The tours include the Hercules Experiment Station, the company's central research laboratories near Wilmington, Del.; the Hopewell, Va., cellulose products and chemical cotton plants; and the naval stores plant at Brunswick, Ga.

Dr. Emil Ott, Hercules director of research, and other members of the research staff, arranged the visits as a means of promoting better understanding between university and industrial research men. The trips show how research is integrated with chemical production.

So far, students from Massachusetts Institute of Technology and the University of Illinois have been flown in. More trips for other universities are planned for the fall.

Rowand Named Chief Engineer of The Babcock & Wilcox Company

W. H. Rowand has been named chief engineer of The Babcock & Wilcox Company filling a new position created by the recent promotion of Alfred Iddles to the presidency of the company. Rowand who will assume most of the engineering activities previously handled by Iddles, has been with Babcock & Wilcox for 19 years during this time he has served in many engineering capacities and has been active in the design and development of boilers.

ACF Directors

American Car and Foundry Company has elected James A. Farrell, Jr. and William F. Van Deventer to the board of directors to fill existing vacancies.

It's Now "Armco"

The name of The American Rolling Mill Company was officially changed effective April 17 to "Armco Steel Corporation."

"Our trade name 'Armco' has been the theme of national consumer advertising since 1914, and has been emphasized in all publicity since then. The Armco trademark has been used on our products and on many of the products of our customers. As a result, our Company for many years has been best known as Armco," President Charles R. Hook explained.

Tank Lining Engineer Named for West Coast

Charles A. Oostdyk, Jr., has been named tank lining field engineer for the West Coast district of Goodyear Tire & Rubber Company's mechanical goods division. Oostdyk will supplement the work of Goodyear engineers in Akron and Los Angeles, and supervise the installation of rubber-lined equipment. His headquarters will be in Los Angeles, where R. G. Abbott is Goodyear district manager.

Thermo-Chemistry Chief Speaks to Calco Group

Dr. Frederick D. Rossini, chief of the Section on Thermo-Chemistry and Hydrocarbons of the Bureau of Standards, spoke recently on the subject, "Fractionation Analysis and Purification of Hydrocarbons," at a meeting of the research, process development and engineering personnel of the Calco Chemical Division, American Cyanamid Company, at Bound Brook, N. J.

Dr. Rossini discussed in detail the four methods used for the isolation and purification of hydrocarbons, namely, distillation, extraction, adsorption and crystallization. He said the Bureau of Standards has perfected to a high degree the use of physical methods of separation, purification and analysis. A report by Dr. Rossini recently appeared telling of the work conducted at the National Bureau of Standards, dealing with the separation of pure compounds from petroleum and with the purification and determination of purity of hydrocarbons.

PETROLEUM REFINER CLASSIFIED ADS

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Draftsmen—Design and piping draftsmen familiar with refinery equipment and piping layouts. Communicate with E. M. Skinner, Chief Engineer, Socony-Vacuum Oil Co., Inc., P. O. Box 546, Augusta, Kansas.

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